REPORT

OF THE

TWENTY-FIFTH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT GLASGOW IN SEPTEMBER 1855.

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Page 87, line 6, *for* a dextral and not a sinistral, *read* a sinistral and not a dextral.

OBJECTS AND RULES

OF

THE ASSOCIATION.

OBJECTS.

The Association contemplates no interference with the ground occupied by other Institutions. Its objects are,—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another, and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

ADMISSION OF MEMBERS AND ASSOCIATES.

All Persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions, shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee, shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

COMPOSITIONS, SUBSCRIPTIONS, AND PRIVILEGES.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this Subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*: but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

Associates for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes :—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.

2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.

3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]

4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]

5. Associates for the year, subject to the payment of One Pound.

6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz. :—

1. *Gratis*.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members who have not intermitted their Annual Subscription.

2. *At reduced or Members' Prices*, viz. two-thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members, who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the first seventeen volumes of Transactions of the Association, *and of which more than* 100 *copies remain*, at one-third of the Publication Price. Application to be made (by letter) to Messrs. Taylor & Francis, Red Lion Court, Fleet St., London.

Subscriptions shall be received by the Treasurer or Secretaries.

MEETINGS.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee at the previous Meeting; and the Arrangements for it shall be entrusted to the Officers of the Association.

GENERAL COMMITTEE.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons :—

1. Presidents and Officers for the present and preceding years, with authors of Reports in the Transactions of the Association.

2. Members who have communicated any Paper to a Philosophical Society, which has been printed in its Transactions, and which relates to such subjects as are taken into consideration at the Sectional Meetings of the Association.

3. Office-bearers for the time being, or Delegates, altogether, not exceeding three in number, from any Philosophical Society publishing Transactions.

4. Office-bearers for the time being, or Delegates, not exceeding three, from Philosophical Institutions established in the place of Meeting, or in any place where the Association has formerly met.

5. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing for the meeting of the year by the President and General Secretaries.

6. The Presidents, Vice-Presidents, and Secretaries of the Sections are *ex officio* members of the General Committee for the time being.

SECTIONAL COMMITTEES.

The General Committee shall appoint, at each Meeting, Committees, consisting severally of the Members most conversant with the several branches of Science, to advise together for the advancement thereof.

The Committees shall report what subjects of investigation they would particularly recommend to be prosecuted during the ensuing year, and brought under consideration at the next Meeting.

The Committees shall recommend Reports on the state and progress of particular Sciences, to be drawn up from time to time by competent persons, for the information of the Annual Meetings.

COMMITTEE OF RECOMMENDATIONS.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects, shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee, unless previously recommended by the Committee of Recommendations.

LOCAL COMMITTEES.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

OFFICERS.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer, shall be annually appointed by the General Committee.

COUNCIL.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

PAPERS AND COMMUNICATIONS.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

ACCOUNTS.

The Accounts of the Association shall be audited annually, by Auditors appointed by the Meeting.

I. Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S.L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, F.R.S., Astronomer Royal, &c. John Dalton, D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MAKDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robison, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, F.L.S., &c. Wm. Hutton, F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	Marquis of Northampton. Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount Edgecumbe.	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.

The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	Earl of Listowel. Viscount Adare. Sir W. R. Hamilton, Pres.R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S. The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. Professor Powell, F.R.S.	Henry Clark, M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. Rev. Wentworth Ackland, Esq., B.M.
The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. Sir H. T. De la Beche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's	Matthew Moggridge, Esq. D. Nicol, M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S. Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
Sir DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews. EDINBURGH, July 31, 1850.	Right Hon. the Lord Provost of Edinburgh. The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S.L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal. IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich. Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society. BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, M.R.I.A., Pres. R.S. Sir Henry T. De la Beche, F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast. Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D.	W. J. C. Allen, Esq. William M'Gee, M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., & Pres. Camb. Phil. Society. HULL, September 7, 1853.	The Earl of Carlisle, F.R.S. Lord Londesborough, F.R.S. Professor Faraday, D.C.L., F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Philos. Society. William Spence, Esq., F.R.S. Lieut.-Col. Sykes, F.R.S. Professor Wheatstone, F.R.S.	Henry Cooper, M.D., V.P. Hull Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge. William Lassell, Esq., F.R.S. L. & E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S.	Joseph Dickinson, M.D., F.R.S. Thomas Inman, M.D.
The DUKE OF ARGYLL, F.R.S., F.G.S. GLASGOW, September 12, 1855.	The Very Rev. Principal McFarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S. L. & E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint. Professor William Thomson, M.A., F.R.S.	John Strang, LL.D. Prof. Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, M.D., F.R.S., Professor of Botany in the University of Oxford. CHELTENHAM, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugall, Esq.

II. Table showing the Names of Members of the British Association who have served on the Council in former years.

Acland, Sir Thomas D., Bart., M.P., F.R.S.
Acland, Professor H. W., B.M., F.R.S.
Adams, J. Couch, M.A., F.R.S.
Adamson, John, Esq., F.L.S.
Adare, Edwin, Viscount, M.P., F.R.S.
Ainslie, Rev. Gilbert, D.D., Master of Pembroke Hall, Cambridge.
Airy, G.B., D.C.L., F.R.S., Astronomer Royal.
Alison, Professor W. P., M.D., F.R.S.E.
Ansted, Professor D. T., M.A., F.R.S.
Argyll, George Douglas, Duke of, F.R.S.
Arnott, Neil, M.D., F.R.S.
Ashburton, William Bingham, Lord, D.C.L.
Babbage, Charles, Esq., F.R.S.
Babington, C. C., Esq., F.R.S.
Baily, Francis, Esq., F.R.S.
Balfour, Professor John H., M.D.
Barker, George, Esq., F.R.S.
Bell, Professor Thomas, F.L.S., F.R.S.
Bengough, George, Esq.
Bentham, George, Esq., F.L.S.
Bigge, Charles, Esq.
Blakiston, Peyton, M.D., F.R.S.
Boileau, Sir John P., Bart., F.R.S.
Boyle, Right Hon. David, Lord Justice-General, F.R.S.E.
Brand, William, Esq.
Breadalbane, John, Marquis of, K.T., F.R.S.
Brewster, Sir David, K.H., D.C.L., LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonard, St. Andrews.
Brisbane, General Sir Thomas M., Bart., K.C.B., G.C.H., D.C.L., F.R.S.
Brooke, Charles, B.A., F.R.S.
Brown, Robert, D.C.L., F.R.S.
Brunel, Sir M. I., F.R.S.
Buckland, Very Rev. William, D.D., Dean of Westminster, F.R.S.
Burlington, William, Earl of, M.A., F.R.S., Chancellor of the University of London.
Bute, John, Marquis of, K.T.
Carlisle, George Will. Fred., Earl of, F.R.S.
Carson, Rev. Joseph.
Cathcart, Lt.-Gen., Earl of, K.C.B., F.R.S.E.
Chalmers, Rev. T., D.D., late Professor of Divinity, Edinburgh.
Chance, James, Esq.
Chester, John Graham, D.D., Lord Bishop of.
Christie, Professor S. H., M.A., Sec. R.S.
Clare, Peter, Esq., F.R.A.S.
Clark, Rev. Prof., M.D., F.R.S. (Cambridge).
Clark, Henry, M.D.
Clark, G. T., Esq.
Clear, William, Esq.
Clerke, Major Shadwell, K.H., R.E., F.R.S.
Clift, William, Esq., F.R.S.
Cobbold, John Chevalier, Esq., M.P.
Colquhoun, J. C., Esq., M.P.
Conybeare, Very Rev. W. D., Dean of Llandaff, M.A., F.R.S.
Corrie, John, Esq., F.R.S.
Crum, Walter, Esq., F.R.S.
Currie, William Wallace, Esq.
Dalton, John, D.C.L., F.R.S.
Daniell, Professor J. F., F.R.S.
Dartmouth, William, Earl of, D.C.L., F.R.S.
Darwin, Charles, Esq., F.R.S.
Daubeny, Prof. Charles G. B., M.D., F.R.S.
De la Beche, Sir Henry T., C.B., F.R.S., Director-General of the Geological Survey of the United Kingdom.
Dillwyn, Lewis W., Esq., F.R.S.
Drinkwater, J. E., Esq.
Durham, Edward Maltby, D.D., Lord Bishop of, F.R.S.
Egerton, Sir Philip de M. Grey, Bart., M.P., F.R.S.
Eliot, Lord, M.P.
Ellesmere, Francis, Earl of, F.G.S.
Enniskillen, William, Earl of, D.C.L., F.R.S.
Estcourt, T. G. B., D.C.L.
Faraday, Professor, D.C.L., F.R.S.
Fitzwilliam, Charles William, Earl, D.C.L., F.R.S.
Fleming, W., M.D.
Fletcher, Bell, M.D.
Forbes, Charles, Esq.
Forbes, Professor Edward, F.R.S.
Forbes, Professor J. D., F.R.S., Sec. R.S.E.
Fox, Robert Were, Esq., F.R.S.
Frost, Charles, F.S.A.
Gassiot, John P., Esq., F.R.S.
Gilbert, Davies, D.C.L., F.R.S.
Graham, Professor Thomas, M.A., F.R.S.
Gray, John E., Esq., F.R.S.
Gray, Jonathan, Esq.
Gray, William, jun., Esq., F.G.S.
Green, Professor Joseph Henry, F.R.S.
Greenough, G. B., Esq., F.R.S.
Grove, W. R., Esq., F.R.S.
Hallam, Henry, Esq., M.A., F.R.S.
Hamilton, W. J., Esq., Sec.G.S.
Hamilton, Sir William R., Astronomer Royal of Ireland, M.R.I.A.
Harcourt, Rev. William Vernon, M.A., F.R.S.
Hardwicke, Charles Philip, Earl of, F.R.S.
Harford, J. S., D.C.L., F.R.S.
Harris, Sir W. Snow, F.R.S.
Harrowby, The Earl of, F.R.S.
Hatfeild, William, Esq., F.G.S.
Henry, W. C., M.D., F.R.S.
Henry, Rev. P. S., D.D., President of Queen's College, Belfast.
Henslow, Rev. Professor, M.A., F.L.S.
Herbert, Hon. and Very Rev. William, late Dean of Manchester, LL.D., F.L.S.
Herschel, Sir John F. W., Bart., D.C.L., F.R.S.
Heywood, Sir Benjamin, Bart., F.R.S.
Heywood, James, Esq., M.P., F.R.S.
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BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE GENERAL TREASURER'S ACCOUNT from 18th Sept. 1854 (Liverpool Meeting) to Sept. 12, 1855 (at Glasgow).

RECEIPTS.

				£	s.	d.
To Balance brought on from last year's account				96	15	6
Life Compositions at Liverpool and since				260	0	0
Subscriptions of Annual Members ditto do.				414	0	0
Associates' Tickets at Liverpool				765	0	0
Ladies' Tickets ditto				524	0	0
Composition for future Reports				5	0	0
FROM THE SALE OF PUBLICATIONS:						
Reports of Meetings	£106	15	4			
Catalogues of Stars and Dove's Distribution of Heat over the Globe	65	16	0			
				172	11	4
Twelve months' Dividend on £3500, 3 per cent. Consols				98	8	9
Liverpool Bank for Interest on Balance of Account				29	15	2
				£2365	10	9

PAYMENTS.

				£	s.	d.
By paid Expenses of Liverpool Meeting, Sundry Printing, Binding, Advertising, and Incidental Payments by the General Treasurer and the Local Treasurers				332	5	6
Printing Report of the 23rd Meeting, Engraving, &c.				385	7	3
Salaries, 12 Months				350	0	0
Maintaining the Establishment of Kew Observatory				425	0	0
Earthquake Movements				10	0	0
Physical aspect of the Moon				11	8	5
Vitality of Seeds				10	7	11
Map of the World				15	0	0
Ethnological Queries				5	0	0
Dredging near Belfast				4	0	0
Balance at the Bankers	£812	7	11			
Balance in General Treasurer's hands	6	1	7			
	818	9	6			
Due to Local Treasurers	1	7	10			
				817	1	8
				£2365	10	9

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REPORT OF THE PROCEEDINGS OF THE COUNCIL IN 1854–55, AS PRESENTED TO THE GENERAL COMMITTEE AT GLASGOW, WEDNESDAY, SEPTEMBER 12TH, 1855.

1. In reference to the sum of £500 placed by the General Committee at Liverpool at the disposal of the Council for the maintenance of the Establishment at Kew, the General Committee will find in the subjoined Report of the Superintending Committee of that Establishment, an account of the various objects which have occupied their attention, and of their proceedings during the past year. The Council have directed printed copies of this Report to be laid upon the table as the best means of enabling those members of the General Committee who have not personally visited Kew, to form their own judgment of the nature and value of the services which have been performed there, and of the thanks which are due to the Superintending Committee for their voluntary and untiring labours in conducting the Establishment, and to the personal staff, by whom their wishes have been most zealously and effectively carried out. By the perusal of this Report the Council consider also, that the General Committee will be better able to judge of the claims of the Kew Establishment to the approval and to the continued support of the British Association, than by any comments of their own with which the Council might have accompanied the Report *.

* See p. xxx.

2. The Council have also directed printed copies to be laid on the table of a Report which has been presented by the Parliamentary Committee of the British Association, on the question, "Whether any measures could be adopted by Government or Parliament to improve the position of Science or its Cultivators in this Country*."

The suggestions which this Report contains are numerous and important. Some of them, such as those touching alterations in the system of education in our Universities, and an increased encouragement to the formation of museums and public libraries, seem to be already in a fair way of being in a greater or less degree adopted. The suggestion that the principal Scientific Societies shall be located in London at the public expense in some one central building, is, as there is good reason to hope, in a fair train of being realized, under the most favourable circumstances, within the walls of Burlington House in Piccadilly; and such a result would be of the highest importance, not only for the convenience which such a juxtaposition would afford to members for the pursuit of their researches, but perhaps still more from the advantage of presenting the various scientific bodies, and in their persons science itself, to the public eye in a conspicuous, honourable, and influential position.

Other suggestions of the Parliamentary Committee, such as those touching the support by the State of lecturers on science in the provincial towns,—touching the question of rewards to be given in various shapes to the cultivators of science, and more especially that of the creation of a Board of Science which shall advise the Government in connexion with it, have yet to receive that sanction from public opinion, and more especially from the opinion of men of science themselves, which more extended discussion can alone elicit, and without which they could not be pressed upon Government or Parliament with any prospect of success. For such a discussion perhaps the present meeting may present a fitting opportunity.

3. In reference to the recommendation of the General Committee, that the shipowners and other gentlemen interested in navigation at Liverpool should form a Committee of their own body for the purpose of inquiring into the best means of obviating the inconveniences and losses occasioned by the errors of the compasses produced by the iron employed in the construction and equipment of ships, the Council have had the satisfaction of learning that a Committee has been formed and has entered upon the inquiry.

4. The Council have added to the list of Corresponding Members of the British Association the names of Monsieur Léon Foucault and the Abbé Moigno.

5. The Council have been informed that a Deputation will attend at Glasgow for the purpose of conveying an invitation to the British Association to hold its meeting in 1856 at Cheltenham.

Letters have also been received, and will be laid before the General Committee, from the Board of Trinity College in Dublin, from the Royal Irish Academy, and from the Royal Dublin Society, inviting the British Association to hold its meeting in 1857 at Dublin.

* See p. xlviii.

Report of the Kew Committee, presented to the Council of the British Association June 27, 1855.

The Committee beg to submit the following Report of their proceedings since the meeting of the Association at Liverpool.

On the 20th of October last, Mr. John Phillips addressed a letter to the Chairman of the Kew Committee, announcing that a sum of £500 had been placed by the General Committee at the disposal of the Council for the maintenance of the establishment at Kew, and that the General Committee had recommended that application should be made by the President to Her Majesty's Government for the use, rent free, of the two acres of land adjacent to the Observatory, and for the laying-on of gas.

The Committee met on the 8th of November, when the fixed expenditure for the year was estimated at £341 (viz. Mr. Welsh £150, Beckley £91, Magrath £40, and house expenses £60).

It having been represented to the Committee that Her Majesty's Government were anxious that magnetical and meteorological instruments, showing the state to which they had advanced in this country, should be exhibited at the Paris Exhibition, and that the expenses which might be incurred on any instruments or apparatus forwarded by the Committee would be defrayed by the Government, your Committee requested Colonel Sabine, Mr. Welsh, and the Chairman, to attend the Royal Society Paris Exhibition Committee, to explain that the Kew Committee would most readily afford every assistance in their power to carry out the wishes of Her Majesty's Government.

The sum of £140 was ultimately awarded by the Royal Society Committee for this purpose, and the instruments have been prepared and forwarded to Paris.

The following letter from Mr. John Welsh, addressed to the Chairman of the Committee, is presented as a part of this Report.

"Kew Observatory, June 26, 1855.

"Dear Sir,—Colonel Sabine furnished, from the Stores in the department under his control at Woolwich, several of the instruments which had been in use at the British Colonial Magnetical Observatories; and he also procured to be sent from Messrs. Jones and Barrow such of the smaller portable instruments as are employed in magnetical surveys.

"At the Observatory, specimens of the self-recording magnetical and meteorological instruments of Mr. Ronalds were put in order, several small alterations in their adjustments being necessary in order to adapt them to the circumstances of the Exhibition. The two instruments sent, viz. the Bifilar Magnetograph and the Barometrograph, were sufficient to illustrate in every particular the principle of Mr. Ronalds's method of recording magnetical and meteorological phænomena; whilst a few specimens of the actual work of these instruments served to show the degree of accuracy of which they were capable.

"Portions of an electrical apparatus were so arranged as to illustrate the methods of insulation and of observation employed in the larger atmospheric electrometer of Mr. Ronalds.

"A complete meteorological thermometer-stand, similar to the one actually in use at the Observatory (described in the Report of the Kew Committee to the meeting at Liverpool, 1854), was constructed under my own superintendence, and furnished with instruments chiefly graduated by myself.

"Some of the standard thermometers graduated at the Observatory have

been sent; and an apparatus similar to that employed here in the verification of thermometers has been constructed, and is exhibited in working order.

"The meteorological instruments made use of in the balloon ascents of 1852 were put in order, and arranged for exhibition exactly in the condition in which they were employed in the ascents.

"The following instruments were made by my direction expressly for the Exhibition:—

"An Evaporation-gauge on the principle of Mr. Ronalds.

"A common circular Rain-gauge.

"A portable Boiling-point apparatus (the thermometer graduated by myself), on the principle of Regnault's large instrument.

"At the request of the Committee, Mr. Adie furnished a specimen of the marine barometers constructed by him, and recommended by the Committee to the British and American Governments. Messrs. Negretti and Zambra, and Messrs. Casella and Co., also furnished specimens of the marine thermometers constructed by them under the superintendence of the Committee.

"In order to render the collection of meteorological instruments more complete, the Committee requested instruments to be sent by the following London opticians, viz.—

"By Mr. Newman, a Standard and a Portable Barometer.

"By Mr. Barrow, a Standard Barometer; and

"By Mr. Adie, a Standard and a Portable Barometer, and a Portable Robinson's Anemometer.

"The instruments having been prepared and collected at Kew, glass cases and other fittings required for their proper exhibition and protection were constructed, and the whole packed and forwarded on April 10th to the shipping agents appointed by the Board of Trade, by whom they were transmitted to Paris.

"Having learned that the instruments had arrived in Paris, and that the space allotted for their exhibition was in readiness; on May 9th, accompanied by Mr. Beckley, I proceeded to Paris for the purpose of arranging the Collection. Owing to certain arrangements of the Imperial Commissioners, I could not proceed with the necessary preparations until the 17th of May. On June 2nd, the instruments having been all put in order, we returned to the Observatory.

"The space assigned to the Kew Collection is situated near the middle of the South Gallery in the Central Building. It consists of a counter space 25 feet long, and an open space 25 feet long by 7 feet wide. On the counter are placed two glass cases, each 10 feet long, the one containing the smaller Magnetical Instruments, and the other the Meteorological Instruments. On the counter are also placed Mr. Ronalds's Self-registering Magnetograph, and the apparatus for the verification of thermometers.

"On the open space are placed the three large Magnetical Instruments used in the Colonial Magnetical Observatories, with the Reading Telescopes, supported by wooden Tripod Stands; the Self-recording Barometer and Electrical Insulator of Mr. Ronalds; and the Kew Thermometer Stand.

"There is also on this space a Stand containing a copy of the Magnetical and Meteorological Observations made at the British Colonial Observatories, surmounted by Mr. De la Rue's model of the Tower proposed to be erected at Kew for the Huyghenian Telescope.

"The various instruments, especially the magnetical, have been put, as far as was practicable, in a state of approximate adjustment. In order to avoid the effect of tremor in the floor, the magnets have been supported on blocks in such a way as to render the scales visible. All the instruments

have affixed to them descriptive labels in French and English. The annexed copy of these labels will best explain the nature of the collection.

"The instruments exhibited by the Kew Committee have been put in charge of M. de Fontaine Moreau, who has agreed to keep them in good order during the continuance of the Exhibition for the sum of £10. It would, I think, have been of great advantage if there had been, besides, some competent person appointed by the English Commissioners to take a general superintendence of the whole collection of Philosophical Instruments exhibited, and who, being always on the spot, could give any information required by visitors.

"You will see by the account of the expenses, which I have already handed to you, that there has been expended the sum of £141 4*s.* 7*d.*, which already exceeds the amount of the grant from the Board of Trade. Some considerable expense will still be necessary for the protection of the Instruments in Paris, as well as for having them repacked and sent home at the close of the Exhibition. The amount of this I cannot at present estimate, but it will not I believe exceed £50.

"It will be borne in mind that these expenses do not include any return to the funds of the Observatory, on account of the loss of the services of their Assistants during the very considerable period which has been devoted to the preparation of the Instruments and their arrangement in Paris. This period has been little (if at all) short of three months, and the consequent pecuniary sacrifice by the Committee cannot be estimated at less than £60 or £70, independently of the very serious inconvenience sustained in the derangement of the general work of the Observatory.

"I am, dear Sir,

"Yours faithfully,

"J. WELSH.

"To J. P. Gassiot, Esq., F.R.S.,
Chairman of the Kew Observatory Committee.

"*Copy of the Labels affixed to the various Instruments and Apparatus deposited by the Kew Observatory Committee in the Paris Universal Exhibition.*

"1. Declination Magnetometer employed in the British Colonial Magnetic Observatories, under the superintendence of Colonel Edward Sabine, R.A., F.R.S. &c. &c. Constructed by Grubb of Dublin, on the model of the instrument used in the Dublin Magnetic Observatory, under the direction of Dr. Lloyd, F.R.S.

"2. Bifilar Magnetometer, for observations of the variations of the horizontal magnetic intensity, employed in the British Colonial Observatories, under the superintendence of Colonel Edward Sabine, R.A., F.R.S. &c. &c. Constructed by Grubb of Dublin, on the model of the instrument used in the Dublin Magnetic Observatory, under the direction of Dr. Lloyd, F.R.S.

"3. Balance Magnetometer, for observation of the variations of the vertical magnetic intensity, employed in the British Colonial Magnetic Observatories, under the superintendence of Colonel Edward Sabine, R.A., F.R.S. Devised by Dr. Lloyd, F.R.S., and constructed by Robinson of London.

"4. Dip-circle with Microscopes, for observation of the magnetic inclination, furnished with Deflection Bars, for observation of the absolute vertical intensity, by the method of Dr. Lloyd. Constructed by Barrow and Co., London.

"5. Standard Compass used in the British Navy, with Sabine's Deflection Apparatus. Constructed by Barrow and Co., London.

"6. Portable Unifilar Magnetometer, for observation of deflection in the determination of the absolute horizontal intensity by the method of Gauss. Constructed by W. H. Jones of London.

"7. Portable Vibration Apparatus (to accompany the Unifilar Magnetometer), for observations of the time of vibration of the deflecting magnet in experiments for the absolute horizontal intensity, with brass rings for the determination of the moment of inertia of the magnet and its appendages. Constructed by W. H. Jones of London.

"8. Portable Declinometer, with Theodolite and Collimator Magnet, for observation of the absolute declination. Constructed by W. H. Jones of London.

"9. Universal Unifilar Magnetometer, for observations of deflection and vibration in experiments for the absolute horizontal intensity, and (with the addition of a Theodolite) of the absolute declination. Constructed by W. H. Jones of London.

"10. Portable Declinometer, for observations of the variations of the magnetic declination. Constructed by W. H. Jones of London.

"11. Portable Bifilar Magnetometer, for observations of the variations of the horizontal intensity. Constructed by W. H. Jones of London.

"12. Self-registering Magnetometer, for recording photographically the variations of the horizontal magnetic intensity, or of the magnetic declination. Invented by Francis Ronalds, Esq., F.R.S., and constructed under his direction for the Kew Observatory.

"13. Self-registering Barometer, for recording photographically the variations of the atmospheric pressure, with mechanical compensation for the effect of temperature. Invented by Francis Ronalds, Esq., F.R.S., and constructed under his direction for the Kew Observatory.

"14. Apparatus to illustrate the methods of Insulation and Observation employed in the Atmospheric Electrometer, constructed for the Kew Observatory, under the direction of Francis Ronalds, Esq., F.R.S.

"15. Thermometer Stand for Meteorological Observations, similar to that employed at the Kew Observatory; furnished with—

A. Dry- and Wet-bulb Thermometers.
B. Regnault's Condensing Hygrometer, with the Inverting Aspirator of Mr. Ronalds.
C. Daniell's Dew-point Hygrometer.
D. Negretti and Zambra's Maximum-Thermometer.
E. Phillips's Maximum-Thermometer.
F. Rutherford's Minimum-Thermometer.

"16. Standard Barometer by Newman.

"17. Standard Barometer by Barrow and Co.

"18. Standard Barometer by Adie.

"19. Portable Barometer by Newman.

"20. Portable Barometer by Adie.

"21. Marine Barometer by Adie, London, supplied to ships by the British and American Governments, on the recommendation of the Kew Observatory Committee.

"22. Cistern of Adie's Standard or Portable Barometer.

"23. Cistern of Newman's Portable Barometer.

"24. Standard Thermometers graduated at the Kew Observatory by J. Welsh.

"25. Thermometers for Marine Meteorological Observations, supplied to ships by the British and American Governments, on the recommendation of the Kew Observatory Committee.

"26. Evaporation-Gauge, invented by Francis Ronalds, F.R.S, and employed at the Kew Observatory.

"27. Rain-Gauge, with graduated Glass-measure.

"28. Portable Apparatus, for the determination of heights by observation of the boiling-point of water. Constructed on the principle of Regnault's Boiling-point Apparatus for the Kew Observatory.

"29. Meteorological Instruments employed in the experimental Balloon ascents performed in 1852, under the direction of the Kew Observatory Committee, at the expense of the Royal Society of London.

"30. Portable Robinson's Anemometer.

"31. Sliding-rule for the computation of the results of observations of the dry- and wet-bulb hygrometer. Designed by J. Welsh, of the Kew Observatory.

"32. Sliding-rule for computing the variations of the dip and total intensity from observations of the horizontal and vertical components of magnetic intensity. Designed by J. Welsh, of the Kew Observatory.

"33. Apparatus similar to that employed at the Kew Observatory, in the verification of the thermometers supplied to ships by the British and American Governments.

"34. Specimens of the Photographic Records of the Self-registering Magnetometer and Barometer, with apparatus for measuring the ordinates of the curves."

The cost and expenses incurred in the preparation and transit of the instruments and apparatus sent to the Paris Exhibition having exceeded the amount of £140 received from the Board of Trade, and Mr. Welsh having strongly recommended that some arrangement should be made for increased inspection of the instruments and apparatus during the time they remain in the Exhibition,—

The Committee Resolved,—That the Chairman be requested to forward an account of the expenses incurred, amounting to £141 4*s.* 7*d.*, with vouchers, to the Board of Trade, and a list of the instruments exhibited, requesting that a further sum of £50 be granted in order to defray the expenses that must be incurred in repacking and forwarding the instruments to England; and that a copy of the above, and of this Resolution, be sent to the Royal Society's Paris Exhibition Committee, requesting its support of the application.

A copy of the above Resolution, with a list of the apparatus deposited in the Exhibition, has been forwarded to Dr. Lyon Playfair and to the Royal Society.

The apparatus for testing barometers has been completed, and is now in action. This apparatus has been entirely constructed in the Observatory by Mr. Beckley, under the direction and superintendence of Mr. Welsh.

In their last report, the Committee stated that they had engaged to verify for the Board of Trade 400 thermometers and 60 barometers, and for the United States Navy 1000 thermometers and 50 barometers, all of which instruments have now been despatched from the Observatory. The Committee have since undertaken the verification of the following additional instruments, viz.

	For the Board of Trade.	For the Admiralty.
Thermometers	400	480
Barometers..............	60	80
Hydrometers	600	400

Of which there have been already completed 540 thermometers, 800 hydro-

meters, 45 barometers. There have besides been verified for opticians 92 thermometers. The total number of instruments verified up to this time is 2032 thermometers, 155 barometers, 800 hydrometers.

The Chairman has received an application, through Colonel Sabine, from Dr. Pegado, Superintendent of the Royal Marine Meteorological Observatory at Lisbon, for a Kew Standard Thermometer, and for specimens of the Marine Barometers, Thermometers and Hydrometers, supplied to the British Navy and Board of Trade, accompanied by an inquiry whether a supply of such instruments can be obtained for the Portuguese Royal Marine by the aid of the Kew Committee of the British Association, the centesimal scale being employed in the thermometers, and the metrical scale in the barometers. The instruments thus applied for are in course of preparation, and the Kew Committee signified to Dr. Pegado their readiness to undertake the verification of Marine Meteorological Instruments for the Portuguese Government (if desired), under similar arrangements to those which have been approved and adopted by our own Government and by the Government of the United States.

The increased demand on the time and work necessary for the verification of instruments in the Observatory, renders it necessary for the Committee to employ further assistance. As yet the Committee have not been able to obtain the permanent services of any person of the character they require; but in the meantime, Dr. Hermann Halleur, of Berlin, at a weekly salary of 30*s*., on the recommendation of Colonel Sykes, has undertaken for a short time to assist Mr. Welsh in the verification of the instruments.

The Committee has caused a room for magnetic experiments to be erected in the ground, at a cost of about £50.

The apparatus suggested by Sir John Herschel for photographing the spots on the sun's disc, is progressing under the superintendence of Mr. Warren De la Rue. The Solar Photographic Telescope is promised by the maker complete in three months; the object-glass is finished, and some progress has been made with the stand. The diameter of the object-glass is 3·4 inches, and its focal length 50 inches; the image of the sun will be 0·465 inch, but the proposed eye-piece will, with a magnifying power of 25·8 times and focal length x, increase the image to 12 inches, the angle of the picture being about 13° 45′. The object-glass is under-corrected in such a manner as to produce the best practical coincidence of the chemical and visual foci*. The eye-piece consists of two nearly achromatic combinations, their forms, foci, and focal lengths being arranged upon the basis of the photographic portrait lens, the conditions being nearly similar.

It is contemplated to form the system of micrometer-wires on a curved surface; and it may ultimately be found to be advantageous also to curve the photographic screen, as the small curvature necessary, namely about two-tenths of an inch, will present no mechanical difficulties. As in practice it may possibly be found desirable not to produce the sun's image with too great rapidity, a provision is contemplated for the absorption of some of the most energetic active rays by the interposition of coloured media of different tints.

The telescope being for a special object, it will have no appliances except such as appertain exclusively to that object, so that the only means provided for *viewing* the sun will be through the finder intended for facilitating the adjustment of the sun's image in position as regards the micrometer. The

* Mr. Ross has found, that if for the greatest intensity of vision, in common lenses, the ratio of the dispersive powers of the two media is 0·65, the chemical and visual foci will coincide best practically when with the same media the ratio is altered to 0·60; the media he sometimes uses being Pellatt's flint and Thames plate.

polar axis will be furnished with a worm-wheel and clock-work driver, and the declination axis with a clamping circle. A shutter for covering the object-glass, and capable of being rapidly moved by the observer, will be so contrived as to be under his command, whether he be at the time near the object-glass or near the screen, eight feet distant.

It was originally intended to place the telescope in an observatory 12 feet in diameter, provided with a revolving roof; adjoining the observatory, a small room for chemicals was to have been constructed, so as to facilitate the fixing of the pictures. It has however been found possible to somewhat alter the construction of the tube, so as to reduce its length sufficiently to allow of the telescope being placed under the dome of the Kew Observatory, which is only 10 feet in diameter.

Dr. Miller has selected an air-pump for the use of the Observatory, which has been purchased out of the grant of the Royal Society, and is now in the Observatory.

Dr. Robinson's Anemometer, to record the total amount of wind (but not as yet the time or direction), has been constructed at the Observatory, and is now in action.

John P. Gassiot,
Chairman.

Special Report of the Kew Committee relative to the use of Land contiguous to the Observatory, as also to the Lighting of the Building with Gas.

The Committee having ascertained through the Earl of Harrowby, President of the British Association, that in consequence of a recent Act of Parliament no portion of the ground contiguous to the Observatory could be obtained free of rent, and the Commissioners of Parks, Palaces, and Public Buildings having refused to light the Observatory with gas, the Committee consider it their duty to present the following special Report for the consideration of the Council.

Report.

The Observatory was originally placed at the disposal of the British Association by Her Majesty's Government in 1842, and has since been used as a place of deposit for the various books, papers and apparatus belonging to the Association, as well as for the carrying on a continued series of scientific investigations, which have from time to time been fully detailed in its annual reports.

In the Report of the Committee presented to the Association at their Meeting at Hull in September 1853, it was recommended that an application should be made to the Commissioners of Woods and Forests for the temporary use of a small portion of the ground near the Observatory for the erection of suitable places for observing: this recommendation having been approved by the Association, Col. Sabine and the Chairman of the Committee waited on Sir W. Molesworth in January 1854, and explained that the land which the Committee required would not exceed two acres. Sir W. Molesworth stated, that there was some doubt whether the Park was under the control of his Board, but that he would be happy to forward the application.

The Committee not hearing anything further from Sir W. Molesworth, applied to the Hon. Charles Gore, who, at their request, visited the Observatory on the 1st of April, 1854, in company with Mr. Clutton, when it was arranged that the Committee should pay a sum of £10 10*s.* per acre for the use of the land to the tenant, until Michaelmas 1854, at which time it was

stated the present tenure with the Crown would cease, and it being then considered, that at the termination of the agreement arrangements might be made with the Crown for the use of this small portion of the ground; this, however, is now found to be impracticable: the Commissioner having subsequently informed the Committee that he has no intention to determine the present tenancy of the Park, the Committee are therefore precluded from becoming the direct tenants from the Crown, even at a rental (see Letter, 11th April, 1855); and consequently they must either continue to pay the present exorbitant rent of £10 10*s*. per acre, or give up the land to the tenant, although an expense of £48 in fencing, and nearly £50 in the erection of a magnetical house, has been incurred.

In respect to the lighting of the Observatory with gas, the Committee consider that it is highly desirable that this should be effected; for, exclusive of the increase in the general scientific work carried on in the Observatory, the constant attention requisite in the verification of the barometers and thermometers for the use of H.M. Navy and the Mercantile Marine, renders a more perfect and uniform system of lighting highly desirable, as also avoiding the danger of fire by the use of oil lamps.

The Committee having at last ascertained, by correspondence, that the Observatory and the Park are under the control of separate Boards, the Observatory being under the direction of the Commissioners of Parks, Palaces, and Public Buildings, while the Park is under that of the Woods, Forests, and Land Revenues, applied to the Chief Commissioner of the latter department, to ascertain whether he would grant permission to lay down the gas-pipes in the Park, and whether any, and what, amount of compensation would have to be paid to the tenant who rents the land; by the correspondence it will be seen that no compensation will be required, if the gas-pipes are laid down during the winter, and that the Chief Commissioner will not object, provided the Association will undertake to pay a nominal rent of 1*s*. per annum.

The Committee have ascertained that the cost of laying down the gas to the Observatory would be about £220, and in the event of its being considered advisable, all that will now be necessary to obtain is the sanction of the officer of the Parks, Palaces, and Public Buildings department, who has charge of the district, and whose name and address the Committee will endeavour to ascertain.

JOHN P. GASSIOT,
Chairman.

Supplementary Report of the Kew Committee, September 12, 1855.

In addition to the report presented to the Council on June 27, a copy of which is appended, your Committee have now to report that a tube of rather more than one inch internal diameter having been satisfactorily filled with mercury by Mr. Welsh, the standard barometer has been now completed. A detailed account of the various experiments which have been made during the construction of this instrument will be prepared for publication.

The following statement shows the actual number of meteorological instruments verified at the Kew Observatory during the past year:—

	Thermometers.	Barometers.	Hydrometers.
For the United States Government	1000	50	
„ Admiralty and Board of Trade..	1340	200	1269
„ Opticians	180	7	
Total....	2520	257	1269

Apparatus similar to that employed at the Kew Observatory for the verification of barometers and thermometers, has been ordered by the Board of Trade, for the observatory at Liverpool; it has been constructed by Mr. Adie, under the advice and direction of Mr. Welsh; the original patterns used in making the Kew apparatus having been lent for that purpose. The Committee have also been informed that it is the intention of the Admiralty to provide similar apparatus for Portsmouth and Plymouth.

The apparatus necessary for the complete registration of Dr. Robinson's Anemometer is in progress at the Observatory; the castings of all the parts and most of the wheel-work being completed.

The following letter having been addressed by Mr. Welsh to the Chairman, copies were forwarded, by the instructions of the Committee, to Admiral Beechey and Captain FitzRoy at the Board of Trade.

"Kew Observatory, Aug. 27, 1855.

"My dear Sir,—I enclose a memorandum of the number of meteorological instruments which during the past years have been verified for the meteorological department of the Admiralty and Board of Trade, with the sums due to the Kew Committee for the same.

"In the event of further contracts being entered into with the opticians for the supply of meteorological instruments which are to be examined at this observatory, I would offer one or two suggestions with regard to the instruments and the terms of the contracts, with the view of facilitating our proceedings and of securing greater uniformity in the quality of the instruments, and greater punctuality in their delivery.

"1st. As regards the *accuracy* of the graduation of the thermometers, we have, I think, been fully successful; the instruments made by Casella and by Negretti and Zambra have in this respect been constructed with much care, and the numbers rejected on account of error very small. I have not, however, been so well satisfied with regard to the uniformity of the instruments in a mechanical point of view:—the diameter of the bulbs has been too irregular, and in many cases considerably more than is desirable,—the range of the graduation has differed in many instances excessively from that prescribed in the instructions of the Kew Committee,—and even the dimensions of the mere *material* have been too little attended to, at least in some of the instruments more recently made by Negretti and Zambra. With respect to the first two faults, as it is practically impossible to make the instruments *exactly* to a prescribed pattern, I would suggest that certain *limits* should be clearly specified in the contracts, beyond which the instruments must not be in error; for example, 'the diameter of the bulb should be as nearly as possible 0·4 inch, it must not exceed 0·5 inch, nor fall short of 0·3 inch,' and 'the graduation shall extend through $8\frac{1}{2}$ inches of the tube, and shall range from about 10° to 130°, and shall not exceed the limits 0° to 140° or 20° to 130°.' The dimensions of the mere materials should of course be explicitly stated, and no deviation from them be allowed. In the instructions given at first by the Committee, it is stated that 'fluoric or hydrofluoric acid' may be used in etching the divisions: I would suggest that fluoric acid vapour alone should be used.

"2nd. In the case of the hydrometers, it would be well if there existed more uniformity in the form and dimensions of the instruments as made by the three different makers employed by Captain FitzRoy. Those made by Casella are, on the whole, the best adapted for practical work; their scales should, however, be more open. In shape and strength they are by far the best, those by Adie and by Negretti and Zambra being much too

fragile to stand the work they are designed for. In respect to accuracy, Casella's are also incomparably the best, and he deserves credit for the care with which they have been made: I cannot report so favourably of the quality of those by Adie, or Negretti and Zambra. I would recommend that for the future the use of metal hydrometers should be altogether discontinued. They are four times the price of glass ones,—are generally less accurate,—are more apt to give deceptive results from their greater affinity for grease,—are very liable to pick up small particles of mercury,—and, lastly, if they do get a knock, their indications are rendered *false*; whereas a glass one is simply destroyed and no harm is done to the observations.

"3rd. I have no particular remark to make about the marine barometers by Adie; they continue to improve in quality and regularity as the maker becomes more familiar with the work.

"4th. With regard to punctuality in the delivery of the instruments;—there is, I understand, in the contracts, a clause to the effect that if the instruments are not delivered at certain dates, the Board of Trade or Admiralty are at liberty to purchase the instruments elsewhere, the defaulter to pay any difference in the cost. Now such a penalty might do very well if we had to deal with articles which are to be had at any time of the same quality. As it is, the instruments are not to be had in an emergency by simply sending into the market. I do not mean that barometers and thermometers may not be had in abundance, but we know, from past experience, that they are not of a quality which it would be desirable to give out for accurate observations. Such a penalty becomes therefore practically inoperative. I would suggest, whether a direct pecuniary fine should not be rather imposed in cases of default. If the punctual delivery of the instruments by the makers were rigorously enforced, I should then be able so to arrange beforehand the work of the Observatory, that the verifications should in all cases be proceeded with promptly and regularly. The want of punctuality hitherto has frequently been a source of serious inconvenience to the Observatory.

"It would, I believe, contribute much to regularity, if the thermometers and hydrometers were sent here in the boxes, just as they are to be delivered to the ships: the additional expense would be very trifling,—perhaps a halfpenny on each instrument.

"I remain, dear Sir, yours faithfully,

"*J. P. Gassiot, Esq., F.R.S.*" "J. WELSH."

The following reply has been received from the Board of Trade:—

"Office of Committee of Privy Council for Trade, Marine Department,
4th September, 1855.

"SIR,—I am directed by the Lords of the Committee of Privy Council for Trade to acknowledge the receipt of your letter of the 31st ultimo, enclosing a copy of a letter from Mr. Welsh, having reference to certain arrangements which he proposes should be made with instrument-makers in the case of future contracts for meteorological instruments; I am to convey to you their Lordships' thanks for the communication, and to inform you that they will adopt Mr. Welsh's suggestions.

"I am, Sir, your obedient Servant,

"DOUGLAS GALTON, Capt. R.E."

"*John P. Gassiot, Esq., Chairman of the Kew Committee,
British Association, Kew Observatory.*"

Two portable barometers by Adie, previously compared with the standard

at Kew, were deposited for a few days at the Imperial Observatory at Paris; comparisons with the standard instrument of the Observatory were taken by M. Liais, which indicated that the standards of the two Institutions do not differ from each other by one-thousandth of an inch.

In the report of the Committee presented to the Association at the Liverpool Meeting, it is stated that—"Considering the variety and importance of the objects which are now being carried out at the Observatory, the Committee submit for the consideration of the Council, that should the financial state of the Association at Liverpool justify an increase in the annual sum placed at the disposal of the Committee, they feel confident that a larger grant than has been allowed in the last few years for the maintenance of the Observatory, might be so appropriated in the next year with great advantage to the interests of science and to the credit of the Association." The Association responded to this request by placing the sum of £500 at the disposition of the Kew Committee. The Committee hope that the account of disbursements and the report now presented will satisfy the Association that the money expended during the past year has not been misapplied. Should the financial position of the Association justify the expenditure, the Committee hope that a similar amount of £500 may be awarded for the current expenses of the Kew Observatory for the ensuing year.

The Committee cannot close this report without alluding to the advantages which are likely to arise from the endeavours used by the Association to improve the construction of meteorological instruments, and at the same time to reduce their price. Independently of the improvement which the Committee have been able to introduce in the manufacture of instruments for the use of the Royal and Commercial Marine, they are gratified by perceiving an increasing disposition among the makers generally to bestow more care upon the construction of their instruments.

(Signed) JOHN P. GASSIOT,
Chairman.

CORRESPONDENCE REFERRED TO IN PRECEDING REPORT.

1. *Mr. Gassiot to the Hon. Charles Gore.*

"Clapham Common, 20th March, 1855.

"SIR,—You are I believe aware, that some years since H.M. Government placed the Observatory in the Old Deer Park, at Richmond, at the disposal of the British Association, with the view of its being used not only for the deposit of the various scientific instruments and apparatus as well as books belonging to the Association, but also for the carrying on of various scientific experimental investigations.

"Much inconvenience has arisen in the prosecution of the latter, from the Observatory not being properly lighted, and I have been requested by the Committee to suggest to you the advisability of the interior of the building being lighted with gas.

"Exclusive of the desirableness of the gas being laid on, as has been done in the Magnetical and Electrical Department of the Royal Observatory at Greenwich Park, and in the event of which the Committee would be enabled to carry out a variety of scientific investigations which they are now totally prevented from commencing, I may state that the increased requirements arising from the number of barometers and thermometers, which are at present in course of verification for the use of H.M. Navy and Mercantile Marine, has rendered it indispensable that a corresponding

increase should be made in the number of oil lamps, and the Committee cannot but be sensible that in a building in which so large a quantity of papers and books is distributed, a corresponding increase in the danger of fire has arisen; this would be entirely obviated by the introduction of gas into the building.

"Limited as are the funds which are at the disposal of the Association, the expense of the gas proposed to be used would be defrayed by the Committee, and all they ask is that it should be laid on in the different rooms. The Committee hope that as no pecuniary assistance is received by the Association from H.M. Government, and that as the exertions of the Committee have latterly been devoted to the great national object of verifying the meteorological instruments used by H.M. Navy, this request will not be refused.

"Some time since, the Committee made arrangements through your Surveyor, with the present tenant, for the occupation of two acres of the land immediately contiguous to the Observatory; the land has been enclosed with a strong paling at a very considerable expense.

"In any future letting, the Committee hope they will be permitted to take the two acres direct from the Crown, at such rent as your Surveyor may consider fair and equitable; and as some misunderstanding has at times arisen as to the right of way to the Observatory, the Committee would feel obliged in any future arrangements you may make for the letting of the land, that the right of way should be specified.

"I am also directed to acquaint you, that the Committee consider it desirable the Building should be examined by your Surveyor, as some repairs are required, which if not made at an early period, may ultimately cause considerable expense to the Government.

"I have the honour to be, Sir,
"Your obedient Servant,
(Signed) "J. P. GASSIOT."

"To the Hon. Charles Gore."

2. *Mr. Gore to Mr. Gassiot.*

"Office of Woods, &c., 27th March, 1855.

"SIR,—I have to acknowledge the receipt of your letter of the 20th inst., and to inform you in reply, that the Buildings of the Observatory being under the charge of the Commissioners of Her Majesty's Works, &c., any communication respecting its condition, or as to lighting it with gas, should be made to that Department at No. 12 Whitehall Place, and I have therefore transmitted copy of those portions of your letter which have reference to that Building to that Office.

"With respect, however, to the tenancy of the land adjoining the Observatory, I have to state that in the event of any change in the letting of the Park taking place, your application, that the Committee of the British Association may be permitted to rent it direct from the Crown, and a right of way thereto reserved in the letting of the residue, shall receive attention.

"I am, Sir,
"Your obedient Servant,
(Signed) "CHAS. GORE."

"J. P. Gassiot, Esq."

3. *Mr. Gore to Mr. Gassiot.*

"Office of Woods, &c., 11th April, 1855.

"SIR,—With reference to my letter to you of the 27th ult., I have to acquaint you that I do not think it would be for the interest of the Crown,

and I have therefore no intention to determine the present tenancy of the Old Deer Park. It is not therefore in my power to give to the British Association a direct holding under the Crown of the land adjoining the Observatory and in their occupation; but, as stated in my said letter, in the event of any change in the letting taking place, your application to that effect shall receive attention. "I am, Sir,

"Your obedient Servant,

(Signed) "CHAS. GORE."

"J. P. Gassiot, Esq."

4. *Mr. Gassiot to the Hon. Charles Gore.*

"Clapham Common, 17th April, 1855.

"SIR,—I have the honour to acknowledge receipt of your esteemed favours of 27th ult. and 11th inst. At the time the Committee agreed to give the present tenant the rent which they now pay, they considered (from the conversation they had with you) that the present tenancy terminated next Michaelmas, otherwise they would not have instructed me to make the application, and they cannot but regret it is not in your power to give them a direct holding under the Crown for the small portion of the Park which they at present occupy.

"In your letter of 27th ult., you stated that you had forwarded an extract of that portion of my former letter which referred to the repairs and lighting of the Observatory with gas to another department; I have not received any communication on the subject, and Mr. Welsh informs me that the Observatory has not been visited by any person in reference thereto; for the reasons mentioned in my letter, the Committee would feel obliged if you could assist them in obtaining the lighting of the Observatory with gas; as regards the repairs, unless some early notice is taken, the ultimate expense to Government may be considerable.

"I have the honour to be, Sir,

"Your obedient Servant,

(Signed) "JOHN P. GASSIOT,

"*Chairman of the Kew Committee of the British Association.*"

"To the Hon. Chas. Gore."

5. *Mr. Gore to Mr. Gassiot.*

"Office of Woods, &c., 19th April, 1855.

"SIR,—I have to acknowledge the receipt of your letter of 17th inst., requesting attention to your previous application, with regard to the repairs and lighting of the Observatory in the Old Deer Park with gas.

"In reply I have to acquaint you that I have no power to obtain a reply, and to suggest therefore that any further communication on the subject which you may consider desirable, should be addressed direct to the Chief Commissioner of Her Majesty's Works, &c., No. 12 Whitehall Place, to whom, as stated in my letter of the 27th ult., I had forwarded your previous application. "I am, Sir,

"Your obedient Servant,

(Signed) "CHAS. GORE."

"J. P. Gassiot, Esq."

6. *Mr. Gassiot to the Hon. Sir William Molesworth, Bart.*

"Clapham Common, 26th May, 1855.

"SIR,—On the 20th of last March, by the direction of the Kew Committee of the British Association, I addressed a letter to the Hon. Charles Gore, Chief Commissioner of H.M. Woods, Forests, and Land Revenue Department, of which the following are extracts:—

"'You are, I believe, aware, that some years since H.M. Government placed the Observatory, in the Old Deer Park at Richmond, at the disposal of the British Association, with the view of its being used not only for the deposit of the various scientific instruments and apparatus, as well as books belonging to the Association, but also for the carrying on of various scientific experimental investigations.

"'Much inconvenience has arisen in the prosecution of the latter, from the Observatory not being properly lighted, and I have been requested by the Committee to suggest to you the advisability of the interior of the Building being lighted with gas.

"'Exclusive of the desirableness of the gas being laid on, as has been done in the Magnetic and Electrical Department of the Royal Observatory at Greenwich Park, and in the event of which the Committee would be enabled to carry out a variety of scientific investigations which they are now totally prevented from commencing, I may state that the increased requirements arising from the number of Barometers and Thermometers which are at present in course of verification for the use of H.M. Navy and Mercantile Marine, has rendered it indispensable that a corresponding increase should be made in the number of oil lamps, and the Committee cannot but be sensible that in a Building in which so large a quantity of papers and books is distributed, a corresponding increase in the danger of fire has arisen; this would be entirely obviated by the introduction of gas into the Building.

"'Limited as are the funds which are at the disposal of the Association, the expense of the gas proposed to be used would be defrayed by the Committee, and all they ask is that it should be laid on in the different rooms; the Committee hope that as no pecuniary assistance is received by the Association from H.M. Government, and that as the exertions of the Committee have latterly been devoted to the great national object of verifying the meteorological instruments used by H.M. Navy, this request will not be refused.

"'I am also directed to acquaint you, that the Committee consider it desirable the building should be examined by your Surveyor, as some repairs are required, which if not made at an early period, may ultimately cause considerable expense to the Government.'

"On the 27th March, Mr. Gore replied, stating 'that the Building of the Observatory being under the charge of the Commissioners of Her Majesty's Works, any communication respecting its condition, or as to lighting it with gas, should be made to that department, at No. 12, Whitehall Place, and I have therefore transmitted copy of those portions of your letter which have reference to that Building to that Office.'

"Nearly two months having elapsed without being favoured with any communication from you, I have been directed by the Committee to state, that they should feel obliged by your informing them whether their request can be complied with: I may add, that, in respect to the repairs, these are absolutely necessary, in order to prevent a much larger outlay at no great distance of time. "I have the honour to be, Sir,

"Your obedient Servant,

(Signed) "JOHN P. GASSIOT."

7. *The Secretary of the Board of Works, &c. to Mr. Gassiot.*

"Office of Works, &c., June 2, 1855.

"Sir,—The Commissioners of Her Majesty's Works, &c. have had transmitted to them by the Hon. Charles Gore, one of the Commissioners of Her Majesty's Woods, &c., extracts from your letter to him of the 20th March last, in which you request, on behalf of the British Association, that they may be permitted to burn gas in the Observatory in the Old Deer Park at Richmond, the use of which has been allowed to them, and also that the gas may be laid on to the different rooms free of expense to the Association, they engaging to pay the cost of the gas proposed to be used.

"In reply, I am directed to inform you that the Board have no objection to the use of gas in the building in question, but that the whole of the work must be done by, and at the expense of, the Association, and to the satisfaction of the Board's officer in charge of the district.

"I am, Sir,
"Your most obedient Servant,
(Signed) "J. Thomborrow,
"*Assistant Secretary.*"

"J. P. Gassiot, Esq."

8. *Mr. Gassiot to the Secretary of the Board of Works, &c.*

"Observatory, Old Deer Park, Richmond,
June 7, 1855.

"Sir,—I beg to acknowledge the receipt of your letter of the 2nd instant, wherein you state that, in reply to a communication made by me to the Hon. Charles Gore on the 20th of last March, relative to the lighting of the Observatory with gas, the Board has no objection to the use of gas in the Observatory, but that the whole of the work must be done at the expense of the British Association, and to the satisfaction of the Board's officer in charge of the district.

"In a letter addressed to the Right Hon. the Chief Commissioner, of the 26th ult., but which you have not done me the honour to notice, I explained that, in consequence of the increased requirements arising from the number of barometers and thermometers which are at present in course of verification for the use of Her Majesty's Navy and the Mercantile Marine, it was highly desirable that the Observatory should be lighted with gas.

"The entire outlay attending the important work done in the Observatory has been defrayed by the British Association; and considering that so large a portion consists in the verification of instruments for the use of the Navy, I cannot but regret that so trifling a request should have been so summarily refused; for although upwards of two months have elapsed since the application was made, no one has visited the Observatory from your department to inquire as to the advisability of the application being granted.

"I believe I am also correct in stating, that during the many years the Observatory has been occupied by the Association, no officer from your Board has visited the building. I name this because a portion of my letter referred to its present dilapidated condition, to which the Committee had particularly requested me to draw the attention of your Board.

"I have the honour to be, Sir,
"Your obedient Servant,
(Signed) "J. P. Gassiot."

"J. Thomborrow, Esq.,
Assistant Secretary, Parks, Palaces, &c."

9. *Mr. Gassiot to the Hon. Charles Gore, Esq.*

"Kew Observatory, June 12, 1855.

"Sir,—The Chief Commissioner of Her Majesty's Works not having favoured the Kew Committee with any communication relative to their application to you for the introduction of gas into the Observatory, and which application you informed me, in your letter of the 27th of last March, you had forwarded to him, I addressed a letter to Sir William Molesworth on the 26th ult.; on the 2nd inst. the Assistant Secretary writes me as follows:—

"'I am directed to inform you that the Board have no objection to the use of gas in the building in question, but that the whole of the work must be done by, and at the expense of, the British Association, and to the satisfaction of the Board's officer in charge of the district.'

"The correspondence has been submitted to the Kew Committee, and I am instructed to inquire if you will grant permission for the gas to be laid on to the Observatory through the Park, and whether, in the case of your granting such permission, any, and if so, what amount of compensation will have to be paid to the tenant in possession.

"The Committee are anxious, before they present their Report to the Council of the Association, to be informed as to the total expense they would have to incur in laying on the gas; and as, in a former instance, compensation was to have been paid for the carrying of materials across the Park, the Committee considered it advisable that this should be ascertained before any outlay is commenced. "I have the honour to be, Sir,

"Your obedient Servant,

(Signed) "J. P. Gassiot."

"To the Hon. C. Gore, Chief Commissioner
of Her Majesty's Woods and Forests, Land Revenue."

10. *Mr. Gore to Mr. Gassiot.*

"Office of Woods, &c., June 18, 1855.

"Sir,—In reply to your letter of the 12th instant, I have to inform you, that, provided the gas pipes are laid down as nearly as possible in the direction of the footpath leading from Mr. Fuller's Farm Premises to the Observatory in the Old Deer Park, as requested by you on behalf of the Kew Committee, I am ready to grant the permission sought on payment of an annual acknowledgment of one shilling.

"As regards the compensation to be made to the tenant of the Park, I am informed that if the works are not proceeded with until October next, and completed without interruption, and to the satisfaction of Mr. Clutton, the Crown Receiver, he will not require any compensation; and as Mr. Clutton has been informed by the Superintendent of the Observatory that the pipes will not be required to be laid down until the latter part of the year, I presume that the Committee will not object to accede to this arrangement.

"I am, Sir,

"Your obedient Servant,

(Signed) "Charles Gore."

"J. P. Gassiot, Esq."

Accounts of the Kew Committee of the British Association from Sept. 18, 1854 *till Sept.* 12, 1855.

RECEIPTS.

	£	s.	d.	£	s	d.
Balance from last account				24	13	1½
Received from the General Treasurer				500	0	0
,, from the Government Grant, for thermometer cases supplied				1	16	0
,, for the verification of Instruments—						
from H.M. Government	7	10	0			
from East India Company	15	14	0			
from United States Government	75	0	0			
from Opticians	2	16	0			
				101	0	0
				£627	9	1½

PAYMENTS.

	£	s.	d.	£	s.	d.
Salaries, &c.:—						
To Mr. Welsh, one year	150	0	0			
Ditto, allowed for petty travelling expenses	10	0	0			
Ditto, for expenses in the trials of marine barometers (omitted in last year's account)	11	0	0			
Dr. Halleur, from Mar. 29 to Sept. 13	36	0	0			
Ditto, Gratuity	10	0	0			
R. Beckley, from Sept. 18, 1854 till Sept. 10, 1855, less nine weeks paid from the Government Grant	73	10	0			
J. V. Magrath, one year	40	0	0			
				330	10	0
Apparatus, Materials, Tools, &c.				43	16	6
House Expenses, Coals, Chandlery, &c.				43	7	2½
Ironmonger				15	0	7
Carpenter				22	11	7
Building of Magnetic House				49	0	0
Stationery, Books, Printing, Postage				21	14	9
Porterage and petty expenses				5	6	11
Balance on hand				96	1	7
				£627	9	1½

Report of the Parliamentary Committee of the British Association to the Meeting at Glasgow in September 1855.

The Parliamentary Committee have the honour to Report as follows:—

The labours of the Committee during the past year have been confined to two subjects:

1st. The juxtaposition of the Scientific Societies in some central locality of the Metropolis;

And, 2ndly. The report on the question, Whether any measures could be adopted by the Government or Parliament that would improve the position of Science or its Cultivators in this Country.

As to the first,—

We have co-operated with the Committee of the Memorialists in endeavouring to obtain a reply to the Memorial on this subject presented to Lord Aberdeen, the First Lord of the Treasury, in May 1853, and we have learned from our Chairman that a Deputation of the Memorialists, of which he was a member, had a satisfactory interview with Lord Palmerston on the 30th of June last.

As to the second,—

Your Committee have, since their last Report, received a great many very valuable suggestions, both from those eminent persons who had before done them the honour to reply to their Circular, and from many others occupying distinguished positions as men of science. They have also had the benefit of the assistance of their new colleague, Mr. John Ball, and of others of their own body who had not previously expressed any opinion on the various interesting questions discussed in the Report, as originally framed.

Your Committee maturely considered all these opinions and suggestions, and finally agreed on the Report, which, by permission of your Council, has been already printed and circulated among the Members of the Association*.

Your Chairman has forwarded a copy of this Report to Lord Palmerston and other Members of the Cabinet, and to certain distinguished Members of the Legislature, accompanied by the following letter:—

"Wrottesley, August 1855.

"I have the honour to forward to you a Report, carefully prepared, after consulting many of the most distinguished Cultivators of Science on the interesting question therein discussed.

"The object aimed at was to collect together and enumerate all the present requirements of Science, considered in its relation to the ruling powers and educational establishments of the State; and these various desiderata will be found in the last page of the enclosed Report in the form of ten propositions.

"It must not be inferred from the course which has been taken in preparing this Report, that a necessity is believed to exist for the *immediate* adoption of all its suggestions; but with respect to the tenth and last, viz. the creation of a Board of Science, it may with confidence be affirmed, that this measure would of itself, and at a trifling cost, confer most important benefits on the Government and Nation, and that it deserves early and serious consideration.

"I remain, yours faithfully,
"WROTTESLEY."

* This Report, dated July 14, 1855, is given in pp. 7–22.

Your Committee recommend that Mr. Robert Stephenson, M.P. for Whitby, who is well known as a distinguished Civil Engineer, be appointed to fill the vacancy in their body caused by the death of the late Mr. Vivian.

August, 1855. WROTTESLEY, *Chairman.*

Report presented by the Parliamentary Committee to the British Association for the Advancement of Science at Glasgow, on the question, Whether any measures could be adopted by the Government or Parliament that would improve the position of Science or its Cultivators in this Country.

It will be remembered, that we expressed our intention of presenting a Report on the answers which we had received to the above question from several eminent men of science.

The whole of the subjects discussed in the valuable replies which we have received, or which have occurred to ourselves as material to the issue, may be considered under the three following heads:—

1st. How can the knowledge of scientific truths be most conveniently and effectually extended?

2nd. What inducements should be held out to students to acquire that knowledge; and, after the period of pupilage has expired, to extend it, and turn it to useful account?

3rd. What arrangements can be made to give to the whole body of competent men of science a due influence over the determination of practical questions, dependent for their correct solution on an accurate knowledge of scientific principles?

The proper determination of these three questions appears to us of vital importance to the welfare of the State.

On the first question, *How is the knowledge of science to be extended?* it will hardly be expected that we should enter into details; but it is so intimately connected with the second, that a few words on the subject will not be out of place.

For the purposes of this inquiry, the community may be divided into those who resort to the Universities for education, and those who do not. As to the former, we know of no step that would be more effectual than that which we have already recommended in our Report of last year, viz. that a certain amount of knowledge of physical science should be required from every candidate for a degree. The expediency of this course is strongly urged by Professor Phillips and Mr. Grove in answer to our query, and also by distinguished witnesses who gave evidence to the University Commissioners. Your President, in his late address at Liverpool, has stated it as an undeniable proposition, "that those who administer the affairs of the country ought at least to know enough of science to appreciate its value, and to be acquainted with its wants and bearings on the interests of society."

Mr. Grove observes, "that it is melancholy to see the number of Oxford graduates who do not know the elementary principles of a telescope, a barometer, or a steam-engine. The contempt of anything manual or mechanical, which Bacon so strongly reproved, still prevails to a large extent among the upper classes."

Some evidence was given to the Oxford University Commissioners in reference to the inconveniences suffered by Oxford graduates when thrown suddenly on their own resources, as *e. g.* in a newly-settled country, from their neglect of physical science during their University career.

It must be remembered also, that there is scarcely any profession or vocation in life in which some amount of knowledge of physics may not be a desirable, or even necessary acquisition. The legislator, statesman, and even legal tribunals, through ignorance of the principles of natural science, become the prey of charlatans; and vast sums of money may be squandered on impracticable, unnecessarily costly, or useless projects. In the legal and medical as well as in the naval and military services, a knowledge of scientific principles is most essential, and should be imparted to all; but this is too wide a field to enter upon here.

Now, there can be no doubt, that if Science be made an essential condition for obtaining a degree, it will be taught more extensively at schools, and at the University itself. This will give rise to an increased demand for accomplished professors and teachers, or to some modification of the professorial system calculated to effect this object. The increase in the numbers of teachers, and the necessity for giving increased salaries to ensure high qualifications, will in itself create a variety of lucrative employments; and this, again, will stimulate students to learn that which is capable of affording them a comfortable provision in after-life. The whole machine of instruction will thus act and react to the great benefit of all concerned; and if other stimulants, about to be alluded to, be added, a valuable species of knowledge will rapidly spread among those destined hereafter either to teach or to discharge important functions, or fill high offices in the State.

While recommending, however, that physical science should be required from all candidates for a degree, we admit that a discretion should be left to the University authorities, as to the extent to which this desirable change shall be at first carried into effect, in full confidence that studies so attractive and useful will eventually obtain from all candidates for University degrees that share of attention to which they are so justly entitled.

As to that portion of the population who do not resort to universities for instruction, it is to be hoped that University Reform will diminish the number of this now very numerous class. The best mode of imparting to them instruction in science seems to be that suggested by Mr. Grove and others in their replies to our Circular; that is, that professors, paid either wholly or in part by the State, should be appointed to deliver gratuitous, or very cheap lectures, illustrated by philosophical apparatus, to Institutions, in London and at the principal provincial towns, whose rules of admission and management should have been duly approved; and, when the system has been well organized, it might even be still further extended.

Such lectures would be successful only in proportion as they were followed by examinations and rewards to diligent hearers, who might thus be induced to extend their studies, and assist in the diffusion of sound knowledge.

We are aware that lectures, even though followed by examinations of a nature really calculated to test the degree of attention and ability of the hearers, are by no means a substitute for that course of severe study and mental training which can alone introduce the student to an accurate knowledge of physical science. Lectures, however, even when addressed to men wholly, or almost wholly ignorant of their subject-matter, are very valuable as stimulating curiosity, exciting desire for study, and diffusing a general knowledge of facts and principles, and perhaps enabling attentive hearers at

least to appreciate science; and when addressed to the real student, lectures are useful aids, particularly in those departments which require experimental illustrations*.

On this subject, Professor Phillips, whose skill and experience in imparting oral instruction are so well known and appreciated, has forwarded to us the following remarks. He observes, "that success in teaching depends not merely, or even mainly, on the ability of the teacher: it is much more the effect of his standing *in the right relation to his audience.* For conversational, *i. e.* tutorial teaching, *one* class of mind, for public teaching of large audiences, *another* is required. Again, a teacher, whether by conversation or lecture, must *lead by short strings.* You cannot explain the precession of the equinoxes to a man who does not know what the rotation of the earth means. . . . . University men should be employed for University work; local men for local work. No man can take away from others the ignorance which he has never felt, or sympathised with."

The Professor then proceeds to urge the employment as teachers of persons in the same grade of life as those to be taught.

Sir Charles Lyell contrasts the state of Germany with that of this country in reference to the teaching of physical science. He says, "that in the former country, not only in cities where there are Universities, but almost everywhere in places where there exists a school of considerable size for boys under the usual university age, there is at least one teacher to be found whose business it is specially to give instruction in natural philosophy and history, and who has charge of a collection of natural objects. Frequently these teachers are so much devoted to some one of the branches in which they give instruction, as to be authors of original papers in scientific periodicals. So far is this from being the case in England, that I have visited large cities where there are richly endowed ecclesiastical establishments, where I have in vain inquired for a single individual who is pursuing any one branch of physical science or natural history. Hence it happens that if the townspeople, assisted by some of the gentry and clergy of the neighbourhood, establish a museum, they cannot obtain any scientific aid towards its arrangement and superintendence."

Sir Charles suggests that laymen should be almost invariably selected to fill those Professorships which relate to the departments of science represented in our Association. He suggests also, that if provincial lectureships should be established, five or six towns should be first selected, which have exhibited their taste for scientific knowledge by the foundation of museums and the appointment of curators, such as York and Bristol. The Government might enter into an arrangement with the latter to double their salaries, so as to secure to them a continuation of the local patronage already afforded them, and prevent the new grant from becoming merely a substitute for it.

Mr. William Tite, M.P., observes:—"The practical course to be adopted, and which has, I believe, to some extent, been carried out by private efforts, or the tardy intervention of the State, seems to me to consist, for instance, in the formation of schools of mining in such places as Cornwall, &c.; of schools of arts and sciences in such places as Manchester, &c.; of schools of navigation in Liverpool, &c.; of agriculture in York, &c. Perhaps in all it might be found advisable to found thirty schools or colleges of this description, with (it may be) on the average six professors in each. I would propose that these professors should only be appointed after a severe examina-

* Mr. Ball suggests that, on the payment of a small fee, students should have the privilege of using the Lecturer's apparatus, and making analyses and experiments.

tion before a competent Board; the Board *not* named by the Government, but by the Councils of the Universities, and of the different recognized and chartered scientific institutions. They should be paid by a small fixed salary from the State, but principally by the fees from students, the latter being regulated by the examining Board, or by any municipal council which would undertake to defray the fixed charge, or the cost of the buildings and apparatus necessary. The united body of professors should be entitled to confer honorary degrees, which should in no case convey any description of exclusive privilege. . . . .

"An annual vote of between £18,000 and £27,000 would suffice to carry out this system,—surely a very small sum to be devoted, by a country like England, to the practical scientific education of the people.

"The only measures," continues Mr. Tite, "I should at present wish to see adopted to connect science with public affairs, would be by attaching eminent men to the various Government Boards."

Sir Charles Lemon, whose experience in these matters is well known, decidedly objects to any plan under which *itinerant* lecturers should be employed.

In addition to the direct advantages derivable from lectures, we may remark that the establishment of an enlarged staff of professors and teachers will provide further employment in after-life for students; and the situations will be in themselves so attractive, that many will be induced to accept them, on receiving a moderate remuneration for their services; the rather, that in the interval between their professional labours, time might be found for prosecuting their studies.

That these professors should prosecute those studies by which they have obtained their offices, is most desirable. The scientific character of the nation suffers from this cause, that our English system offers so little inducement to Mathematicians and Physicists to pursue their researches. Young men of twenty-one arrive at a marvellous state of proficiency for their age, and then entirely abandon the exact sciences for various professions; a foundation is laid on which a superstructure worthy of the countrymen of Newton might well be reared, and then the work is abandoned; the student must earn his subsistence, and he cannot earn it by geometrical or physical researches.

We have no fear but that if the above, and other suggestions which we are about to make, should be carried out, the extended desire for acquiring knowledge of the kind in question would create a proportional demand for qualified instructors at all the principal educational establishments in the country, and their emoluments would again augment the desire to learn, both in university and general students.

In addition to the above measures, there is no doubt that much might be done by the Committee of Privy Council and the Department of Science at Marlborough House under the direction of the Board of Trade, towards diffusing a knowledge of physical science among the pupils of primary and secondary schools, and it is with pleasure that we learn that some steps have already been taken in this direction.

We are of opinion also, that means should be adopted for encouraging the foundation of Museums and Public Libraries, accessible to all, in our principal towns; and by degrees all imposts should be abolished which enhance the cost to the public of scientific publications. Donations should also be made to public libraries and educational establishments, of works published at the expense of the nation; such, *e.g.*, as the Geological and Ordnance Surveys.

2ndly. *How are the students and proficients in science to be encouraged?*

The measures which we have above described will not alone be sufficient to effect the object we have in view. However attractive Natural Science may be in itself, and it is impossible to over-estimate the pleasure which its study affords to the majority of minds, it cannot be expected that many men will pursue it to any extent, so long as fellowships and the other university prizes continue to be almost exclusively bestowed upon the students in other departments of knowledge. In Oxford more particularly, to use Mr. Grove's words, "the ἦθος, which has been eulogized by some, is peculiarly antagonistic to the study of physical science. It is true that by the recent statutes physics are recognized, but they are not made compulsory or necessary. . . . . From what I saw when resident at Oxford, the *genius loci* is so far removed from such studies, that, unless they are made compulsory, or tempting prizes are held out, the minds of young men will not for an indefinitely long period be directed into that channel, and thus, though the examination papers will look very well to the public, science will form no integral part of a university education."

Lord Rosse, again, in his last address to the Royal Society, has added his testimony to that of the many eminent men who have deplored in common the neglect of these studies at Oxford. "A man," says he, "having taken a first class *in literis humanioribus*, may be ignorant of physics in the most elementary form, and be incapable of comprehending the first principles of machinery and manufactures, or of forming a just and enlarged conception of the resources of this great country."

And lastly, the Chancellor of Oxford himself has lately advocated the extension of these studies in an eloquent appeal addressed to the University authorities on the occasion of founding the new museum.

That important and instructive public document, the Report of the Oxford University Commissioners, shows how little the rewards now held out to students in mathematics at that university deserve to be denominated "*tempting*;" they are in truth utterly insufficient; and unless the changes about to be introduced, under the auspices of the Parliamentary Commissioners, shall remedy this defect, we greatly fear that the anticipations above expressed by Mr. Grove will only be too well realized.

We are, however, convinced that the well-being of the nation would be greatly promoted by an extension of scientific knowledge among all classes, and that more encouragement in the shape of reward for successful exertion must be provided before that desirable end can be accomplished.

More numerous prizes ought to be provided at our universities; and other rewards and inducements both to study and to the prosecution of scientific research should be held out by the State.

It is important that the endowments of Professors, who are at present very inadequately remunerated, should be augmented. Sir John Herschel mentions the following "as one of the most directly beneficial steps which can be taken by Government for the advancement of science itself, as well as for the general diffusion of its principles: viz. to increase the number, and materially improve the position, of the Professors of its several branches in all our Universities and public educational establishments; and to erect Local Professorships in the chief provincial towns, independent of any University; and more especially to make better and indeed handsome provision in the way of salary, for the Professors of those more abstract branches, which cannot be rendered popular and attractive, and therefore self-remunerating in the way of lectures."

We direct particular attention to the last paragraph, from a conviction of

the importance of the suggestion therein contained. In a subsequent part of this Report, we have inserted a quotation from Professor Liebig relating to this subject.

In a former Report we embodied a correspondence with the then Prime Minister respecting the unsatisfactory manner in which the bounty of Parliament, in the shape of pensions, has been hitherto distributed.

The lamented Professor Forbes says, in the concluding paragraph of his reply to our Circular, "It might be considered, whether it would not be desirable to found a number of scientific pensions, to be assigned, not for *relief*, but for *reward* of good service, like the good-service pensions in the Army. They would often help to free the man of science from drudgery and pot-work, and give him the leisure for original research. They would be better rewards than ribands or stars, or other labels, upon the coats of philosophers."

Mr. Ball seems to doubt the propriety of the suggestion in reference to good-service pensions; he states "that he has a strong sense of the probable evils of anything approaching to a system of Government patronage of scientific men, to which it would be a forward step."

The expediency of resorting to orders, or decorations, or any extension of the present system of bestowing medals, as a means of encouragement to the prosecution of physical researches, has been doubted. So long as the student is *in statu pupillari*, the system of rewarding by medals, or other honorary distinctions, presents little difficulty; but in the case of proficients it is otherwise. In addition to other objections, there is one which in our opinion is deserving of serious consideration; and that is, that it seems difficult to devise any method of bestowing such distinctions that will be satisfactory. The Government are, by the hypothesis, not sufficiently informed; and it will perhaps not be considered desirable that the system of the cultivators of science rewarding one another should receive any important extension. We fear that, in its present limited form, it can be hardly predicated of this mode of conferring distinction that it has worked so well as to be entirely satisfactory. Only those versed in the particular branch of knowledge to be rewarded can properly decide on the merit of the candidate; and the fear that partiality may be imputed to judges, who are either rivals, or will be considered as such by many, is likely both to render the task of decision irksome, and to impair the efficient exercise of the judicial function. Again, the value of a theory, or discovery, can seldom be justly appreciated by contemporaries:—Posterity alone can decide.

Professor Phillips is of opinion that medals should never be bestowed except for work done and published; and that they should never be given for mere mental proficiency; they should be rewards for public service, rather than proofs of *personal merit*.

We believe, however, that, whatever objections may be raised to the mode of distribution, *some* medals are desirable, as incentives to exertion; at the same time, we are aware that there may be persons whose labours are but little affected by these and similar rewards. Engaged in elevated pursuits of an intellectual and attractive nature, and appreciating the pure delights which such researches impart, they are contented with the renown which successful exertion brings in its train, and they weigh not *their own* merits in a nicely-adjusted balance, and with a jealous eye, against those of their rivals in fame, nor calculate the chances of *material* reward. Sufficient it is for them that they have done mankind good service, and that those whom they have benefited have not proved wholly ungrateful.

Professor Faraday, after speaking of the distinctions, both national and

foreign, which may even now be earned, writes, "I cannot say that I have not valued such distinctions; on the contrary, I esteem them very highly, but I do not think I have ever worked for, or sought after them."

The late Professor Moll, of Berlin, in his excellent pamphlet on the state of Science in England, has some remarks on the distribution of orders and medals abroad, which are not calculated to enhance the estimation in which they may be held by any one in this country.

Again, the prosecution of some researches and the reduction and publication of results, are expensive, and beyond the means of many of the ablest and most active cultivators of science. The Wollaston Fund of the Royal Society, the Government grant, and the grants of the British Association afford, in addition to the funds of the various scientific societies, most useful aid, but further assistance is sometimes needed, and would be more so, were science more extensively cultivated, and such assistance might be safely accorded under the conditions hereafter recommended.

The *juxtaposition* of the principal scientific societies in some central locality in the metropolis is a question which has lately excited great interest among the cultivators of science.

Lord Rosse, in his address to the Royal Society in 1853, observes, "The interests of Science appear to me to be deeply involved in the question of providing a suitable building for the scientific societies. . . . If a man, naturally gifted, and well educated, attends scientific meetings, he will feel himself constrained to work, and therefore it is so important for the advancement of knowledge, that able men should be induced to join and attend the different societies; but nothing I think would have greater attractions than a building in a convenient central situation, where the business of Science would be transacted, where there would be access to the best libraries, and where that kind of society most valued by scientific men would always be within reach."

The advantages of this juxtaposition are also shortly set forth in the Memorial on this subject presented to Lord Aberdeen, and are indeed so obvious that they need not be here re-stated at length. Mr. Grove, on this subject, observes, "It should be borne in mind that scientific men have but very limited means of acting on Government; they are politicians in a less degree than any class of Her Majesty's subjects; they consist of men belonging to various classes of society, and whose ordinary occupations differ greatly. Most of the great measures of reform or progress which are effected in this country result from a strong pressure of public opinion, urged on by agitation; and as men of science are peculiarly unfitted for this process, Government might not unreasonably be asked to step out of its usual habits, and to lend Science a helping hand."

Professor Forbes observes, "Science must have a local habitation, and be something more than a name, ere it can make a permanent impression on the somewhat material mind of John Bull. As a man without a home, or, if houseless, without a club, is a doubtful and suspicious personage in the opinion of English householders, so is science a questionable myth whilst unprovided with a visible habitation. A first step, then, towards securing a due and wholesome reverence for science in the minds of the masses, educated and uneducated, is the congregation of the more important Scientific Societies in a central and convenient public edifice, where they shall be lodged at the cost, and by the authority, of the State. The *prestige* thus accorded to the Societies would soon extend to their members."

The Astronomer Royal, on the other hand, conceives that the advantages of juxtaposition have been overrated; but admits that if the measure, recom-

mended hereafter under our third head, be adopted, the propriety of such a Capitol of Science would be more evident.

Having, however, considered this question in all its bearings, we cannot too strongly express our conviction, that the juxtaposition of the principal scientific societies would confer a most important benefit on Science; and almost all concur in this opinion.

Of late years, considerable encouragement has been extended to practical science, and this is praiseworthy, provided that abstract science receive its due measure of support; but the genius of our countrymen is so eminently practical, that there is great fear that the less showy branch may be comparatively neglected. Mr. Grove observes, that in that case, "not only will practical science itself suffer, but the country will lose its position in the scale of nations in all that most exalts them." It would be, in fact, to use a common phrase, a beginning at the wrong end.

This is a subject on which much misconception prevails, and this Report may be read by some to whom the facts about to be stated are not so familiar as they are to those to whom it is primarily addressed. The following statement, therefore, may not be deemed wholly uncalled for. It is not uncommon to hear, or even to read, remarks in which the practical application of scientific truths is lauded at the expense of Science itself, so that it might be inferred, that those from whom such observations proceed were completely ignorant,—1st, of the extent to which the most abstract scientific investigations have often led to the most useful industrial applications; and 2ndly, of the many instances in which observations and experiments, seemingly trivial, and likely to lead to no useful result, have, sometimes after the lapse of years and after having been submitted to a succession of master minds, been elaborated into discoveries of the greatest importance to the progress of civilization, and which do honour to human nature.

These objectors to pure Science have either forgotten, or never learnt, that, in the words of an eminent writer, "the modern art of navigation is an unforeseen emanation from the purely speculative, and apparently merely curious inquiry, by the mathematicians of Alexandria, into the properties of three curves formed by the intersection of a plane surface and a cone."

The Steam-Engine itself, so simple in its origin, and yet so fruitful of great results, derived its most important improvements from the abstract investigations, by Dr. Black and others, into the nature of heat;—though it required the genius of a Watt to make them available in practice.

Some curious properties of chemical substances, when acted on by light, were noted, and then arose the art of Photography, the applications of which both to Science and Art are in course of continual extension. Marvellous properties of light, called its "*polarization*," led to the invention of instruments by which submarine rocks may be discovered, to new modes of detecting the nature of chemical liquids, and to improvements in the art of refining beet-root sugar.

Observations of the magnetism of iron, and on the elasticity of steel and relative expansions of metals, were the origin of the compass and chronometer, without which navigation and commerce (and how many countless blessings follow in *their* train!) would now be in almost as rude a state as in the time of the ancients.

The examination of the properties of gases passing through narrow apertures, showed us how to shield the miner from destruction; and other chemical investigations, how to preserve the sheathing of ships from corrosion—an invention which, from unforeseen and remarkable causes, failed at first, but is now successful.

To say nothing of Astrology and Alchemy, the experiments on the leg of a dead frog were the primary source of the electric telegraph, electro-plating, the power of producing submarine explosions, and of blasting rocks with greater facility and safety, and the other invaluable applications of voltaic electricity to the arts.

The labours of our Geologists teach us how to avoid useless expenditure in searches for minerals where none can by possibility be discovered, and where to seek for materials for our buildings.

Those of the Botanist minister to our health; and the Meteorologist will, in addition to the other important applications of his science, soon be enlisted in the service of navigation. Nor is Science less necessary to excellence in the arts of war than in those of peace; the construction and use of arms, fortification, surveys, rapid locomotion, screw steamers, and so forth, all depend on it for their success. Nor is this all: the calamities and failures in war may often be traced to the inefficient means possessed by governments of distinguishing the really scientific man from the ignorant pretender.

This enumeration might be greatly extended, but sufficient has been said to prove how truly the same distinguished writer above quoted remarks, "No limit can be set to the importance, even in a purely productive and material point of view, of mere thought. The labour of the savant, or speculative thinker, is as much a part of production, in the very narrowest sense, as that of the inventor of a practical art; many such inventions having been the direct consequences of theoretic discoveries, and every extension of knowledge of the powers of nature being fruitful of applications to the purposes of outward life*."

On this subject Professor Liebig observes in a letter to Professor Faraday, dated February 1845, and cited in Lyell's Travels in North America:—"What struck me most in England was the perception that only those works that have a practical tendency awake attention and command respect; while the purely scientific, which possess far greater merit, are almost unknown. And yet the latter are the proper and true source from which the others flow. Practice alone can never lead to the discovery of a truth or a principle. In Germany it is quite the contrary. Here, in the eyes of scientific men, no value, or at least but a trifling one, is placed on the practical results. The enrichment of Science is alone considered worthy of attention. I do not mean to say that this is better; for both nations the *golden medium* would certainly be a real good fortune."

Almost all who have replied to our Circular, or favoured us with suggestions, are opposed to the establishment of Institutes or Academies; nor is there any wish expressed that men of science, as such, should be appointed to high political offices in the State. As Assessors, however, or advisers to executive Boards, the services of scientific men would be highly valuable; and in foreign countries such services are believed to be much in request.

Promotions in the Church have been occasionally made avowedly on the ground of literary merit; but if such claims be admissible, it would seem that scientific acquirements should not be overlooked in an age in which scepticism has been nourished by mistaken views of physical phenomena.

The public offices which ought to be filled by men of science, as such, should be sufficiently well remunerated, both to ensure their acceptance by the most qualified men, and also to render them a desirable object of ambition, and swell the list of tempting prizes for scientific distinction. We believe that, with one single exception perhaps, all these offices are inadequately endowed.

* See Mill's Political Economy, vol. i. p. 52.

Nor is increase of salary all that is required: care should also be taken not to subject men of first-rate eminence in science to the harassing and vexatious interference of men of inferior calibre, uninterested in their pursuits, and unable to appreciate their devotion.

Mr. Ball remarks, "that it is not reasonable to expect that scientific offices in themselves very desirable, and arrived at by a career in itself interesting and attractive, should be rewarded by salaries equal to those which remunerate the devotion of time and industry to pursuits comparatively arid and distasteful . . . . . . but there are a good many offices filled by men of high scientific attainments, which are quite below the level which at the general standard of living befits the position of a gentleman."

It is also worthy of remark, that not only ought the present scientific offices to be placed on a more eligible footing in respect of remuneration, but that there is need for the institution of others answering to that description, which do not now exist.

It would be unfair, however, not to remark, while discussing these matters, that the Government has already taken very important steps in the right direction, and has supplied very pressing wants by the establishment of the Department of Practical Geology, and of the Marine Department of the Board of Trade, and its office for the discussion of nautical and meteorological data. Much yet remains to be done; but these and other acts, having a like tendency, such in particular as the £1000 grant to the Royal Society before referred to, are an earnest that a disposition is not wanting "*to lend Science a helping hand.*"

We observed with pleasure that, in regulating the studies of candidates for employment in India, Physical Science was not forgotten by the eminent men whose signatures are appended to the Report thereon.

It appears to us that the question of the propriety of instituting public examinations, by which the degree of proficiency in knowledge of all candidates for public employment might be tested, is one of great interest, and that its right determination must exercise an important influence on the progress of education in any country.

Finally, under both the above general heads may be classed all measures for facilitating the circulation of scientific publications both at home and abroad—an object the importance of which it is difficult to over-estimate.

3rdly. *How are the proficients in science to make their opinions known and cause them to be respected and adopted?*

We have already stated that late events have shown that a disposition is not wanting in Government to give additional encouragement to Science; and the only way in which we can account for the rejection of some applications for aid, which from time to time have emanated from scientific societies and individuals, and which deserved a better fate, is by supposing that the members of the administration, to whom the applications were made, were either unwilling to prefer a demand for the necessary funds, or had some want of confidence in the judgment of those by whom the requests were preferred.

Now the period at which the application was made may have been deemed an unseasonable one, as for example when the country is involved in war; we should, however, be concerned to see our country placed by any events in the position of being wholly unable to comply with demands of this kind; but for any want of confidence we think that a remedy might be devised, which would relieve the Government from the performance of difficult and invidious duties, and give satisfaction to the cultivators of science at large.

We observe that the Board of Visitors of the Greenwich Observatory has, in the proper discharge of its duties, been often compelled to recommend

large outlays upon that establishment and matters connected with astronomy; and we believe there is no instance on record of the measures recommended being rejected, or even postponed, whatever might be the condition of public affairs, or whatever party might be in power. We believe that this is to be accounted for, in a great measure, by supposing that the Board of Visitors and the Astronomer Royal possess more of the confidence of Government than the governing bodies of societies can hope to acquire. This is probably owing to the permanent nature of this Board, the mode in which its members are appointed, and the kind of quasi connexion with the Government which its particular constitution involves. Again, the late Board of Longitude, and the similar institution in France, afford in like manner illustrations of the superior means possessed by public bodies so constituted of inspiring the ruling powers with confidence in their recommendations, and so causing their opinions to be respected and adopted.

These considerations suggested the question, Whether some Board could not be organized, somewhat after the model of these Boards, but with improvements, which should distribute Government grants, perform for the whole domain of Science the functions which two of the above-mentioned Boards still discharge for Navigation and Astronomy, and moreover act as a referee and arbitrator in matters connected with science brought under its cognizance by Government? At present, in Science, as in Art, Government has no responsible adviser, and the acceptance or rejection of any proposal of a scientific character, or of one for the proper determination of which some knowledge of science is required, depends upon the fiat of those who preside over the several public departments by virtue of qualifications, high it may be for the general purposes of the State, but wholly inadequate to the proper solution of the particular questions at issue.

If such a Board as is above proposed could be constituted, which should acquire and deserve to possess the confidence of the Government and Parliament, it would be clearly for the interests of the nation and of science that it should exercise the above functions. What kind of constitution, then, must be given to the new Board, in order that it may fulfil the above requirements?

We will begin with setting out the opinions of those who have done us the honour to favour us with suggestions, premising that the late Professor Forbes, Colonel Sabine, Admiral Smyth, Sir Philip Egerton, and the Astronomer Royal have all expressed themselves in favour of the establishment of a new Board of Science, though, as might be expected, there is some difference of opinion as to its functions and the mode in which it ought to be constituted.

Professor Forbes, who appears to have reflected much and well on the questions raised in this Report*, says, "I do not think anything like an Institute desirable . . . but I think that some Board, having at once authority and knowledge, should be constituted for the regulation and disposition of Government grants for scientific purposes, such as the assistance and endowment of scientific expeditions, the publication of their results, &c.; matters at present disposed of by capricious, often extravagant, oftener parsimonious, and sometimes pernicious methods. An approximation towards a right course is already made in the case of the disposal of the £1000 grant for assisting scientific researches. Now I would work all Government grants for such purposes as the above mentioned, by a modification of that scheme, viz. through an unsalaried committee, constituted much as the Recommendation Committee is at present, combined with an *endowed staff*, consisting of a

* It is a great source of regret to us, that he was not spared to give us further advice and assistance in the advocacy and carrying out of reforms which he had so much at heart.

salaried representative (always a man of distinguished eminence and authority in his line of research) of each of the following departments:

Mathematics.	Physiology.
Astronomy.	Zoology.
Physics.	Botany.
Mechanics.	Geology.
	Chemistry."

Colonel Sabine considers that the working of the Board of Longitude, whilst Dr. Young was its secretary, affords a model which, with a few and slight modifications, might be extremely suitable for a Board, which should be constituted with a more extended scientific scope.

Admiral Smyth writes, "Now for Science a real boon would be the establishment of a proper Board of Longitude, organized on clear principles, and armed with power tantamount to its responsibility. This great step gained, the cultivators of science would necessarily advance. . . . . A good Board of Longitude is meet for a maritime nation, and would, *de facto*, form its great synod of knowledge." Again he writes, he does not mean a Board constituted as the former one so called, but "a useful institution resembling the French Bureau des Longitudes, a Board managed by unequivocally qualified men, both in talent and vocation, with regular salaries, who are personally responsible for their public proceedings, whether regarding opinions, rewards, or publications. This Bureau is composed of Géomètres, Astronomes, Anciens Navigateurs, Géographes, Artistes, and Adjoints; and there is no doubt but that the model may be improved."

Sir Philip Egerton describes the evils which result to Science from the want of system in entertaining and deciding upon projects, and carrying out the determinations of successive Governments in reference to questions of science. He complains that applications have to be made sometimes to one department, sometimes to another; that Governments are prone to give ear, not to propositions in relation solely to the acquisition and furtherance of pure Science, but to the economic application of scientific principles to the improvement of arts and manufactures; a most essential matter indeed, and properly confided to the Board of Trade, but which ought not to be confounded with the more intellectual process of scientific research. Sir Philip thus proceeds: "The toil and labour of the latter are too apt to be left to the unaided exertions of the scientific drudge, and the Government steps in and reaps the benefit,—the osprey catches the fish, but the sea-eagle appropriates it. The remedy I would propose for this state of things is, the establishment of a Board of Science, to which all questions of a scientific nature might be referred by the Government for consideration. The constitution of this Board might be easily made such as to command the confidence both of the Government and the public; but it should be provided, that only a portion of the members should be dependent on the existence of the ministry of the day. Certain funds might be placed yearly at the absolute disposition of the Board; but all recommendations for the application of large funds would of course require the sanction of the Government."

The Astronomer Royal considers a restriction of the functions of the Board desirable; he thinks that it should *initiate* proposals and *urge* them on the Government; but he objects to its acting as a *general* referee and arbitrator in *all* matters connected with Science.

There is an expression in the letter of Professor Forbes which appears to us to describe, with great propriety, what ought to be the characteristics of the future Board; he says, "*it should have at once authority and knowledge*;"

and after weighing all the above suggestions, and considering the constitution of other Boards established for carrying out nearly similar objects, we think that the new Board should be composed of a certain number of persons holding high official situations in the State, more or less connected with science and education; and others holding scientific offices under the Government; together with the most eminent men in every department of science. With respect to the official class, there can be no necessity that they should be as numerous as in the late Board of Longitude, of which about fourteen persons answering to that description were members. Lord Rosse, the Astronomer Royal, and Admiral Smyth, have expressed opinions unfavourable to the admission of great Officers of State as *ex officio* members of the proposed Board. Admiral Smyth is even opposed to *ex officio* Members altogether, and would have all the Members of the Board elected. In these views of the Admiral we cannot concur; but the expediency of admitting the great Officers at all admits of some doubt. We are unwilling to believe that the free expression of opinion on the part of the other members of the Board would be controlled by the presence of Ministers of State to the extent apprehended by the Astronomer Royal; but an objection to the measure alluded to by Lord Rosse, viz. that these Officers must of necessity, in the great majority of instances, derive their information on the subjects discussed from the discussion itself, is entitled to some weight.

Whatever determination, however, may be adopted in reference to these matters, we are anxious that a principle of stability and permanence should have place in constituting a body which is to exercise such important functions. A certain proportion of the members might perhaps hold their offices for life, as is now the case in the Board of Visitors at Greenwich; but some provision should be made for the retirement of a sufficient number, to ensure the ranks being recruited occasionally by the election of young and rising men in the various departments of science. It may not perhaps be advisable to endanger the success of an application to Government for the establishment of this Board, by adopting the suggestions of those who desire that salaries should be given to several of its members, as such. We may perhaps trust to the ultimate adoption of some of our other recommendations, in which the general public are more directly interested, for providing stimulants to scientific exertion, without seeking for them here.

It will be necessary, however, that a Secretary, with a salary, should be appointed to the Board, and that a place of meeting and deposit for papers should be assigned.

Professor Phillips suggests that the proceedings of the Board should be embodied in an annual report to Parliament, which should be widely circulated; a suggestion in which we entirely coincide.

It will probably be thought right that the functions of the Board should be rather strictly defined in the instrument which constitutes it.

If the working of the Board be satisfactory, and the confidence of Parliament and the public be really acquired, it is hardly taking too sanguine a view to anticipate,—1st, that there will be greater assistance and encouragement given than heretofore to Science, and scientific researches, and the reduction and publication of such researches, in cases where such aid is required; 2ndly, that the necessary funds will be more directly and easily obtained; and, 3rdly, that the influence and authority of such a body of distinguished men will ensure the adoption of all suggestions made or approved by them for the benefit of Science, check improvident and reckless schemes, promote those that are deserving of encouragement, and generally give to Science its due weight and importance in the councils of the nation.

It may be that the union in one Board, of men holding high executive offices in the State, and others who, however distinguished in their own departments of knowledge, have in the course of their pursuits acquired habits of abstraction, which are supposed by some to be unfavourable to the development of administrative capacity, will be attended with beneficial results to the working of the Institution in question, the members of which will learn by degrees to appreciate all that is valuable in the characteristics of each of the sections of which it will be composed.

We think that the new Board ought not to consist of less than about thirty-five members; and if it be objected that this number is too large for business, it must be borne in mind, that most of the work will be done by standing sub-committees for the various departments of science, organized somewhat after the model of the Sections in our own Association, reporting to the general body, who will revise their proceedings. It would be hardly possible to include all those who have a claim to be members, and whose counsel and assistance it is most desirable to secure, if any attempt were made still further to limit the numbers. The late Board of Longitude, though presiding over only one department of science, contained about twenty-seven members.

It is proper to add, that Lord Rosse is doubtful as to the expediency of constituting the new Board of Science, on the ground, principally, that the duties here assigned to it might equally well be performed by the Council of the Royal Society, enlarged for the purpose; and that the Society would be in fact so far superseded by the new body.

We cannot concur in this view. It cannot fairly be contended that the Council of the Royal Society, or any Committee appointed by it, confined as they must necessarily be to the members of one Society, is likely to contain at any time within it such a union and variety of talent as would be concentrated in the new Board, if properly constituted. We believe, moreover, that eminent members of that Society do not entertain the apprehensions of their late President.

The Government again are never likely, as has been before fully explained, to extend as much of their confidence to any one Society, however eminent, as to the proposed Board.

In conclusion, it appears that though your Committee have endeavoured to elicit opinions from members of their own body, and from many eminent cultivators of science, they have the gratification of discovering that none of the suggestions offered, or changes proposed, are of such a nature as to impose any serious difficulty on Government, Parliament, or the Universities, were they at once to concede all that is asked.

Such of the above suggestions as we think deserving of the serious and earnest attention of Government, Parliament, and the Universities, and which we may term our desiderata, may be summed up in the following propositions:—

1st. That reforms shall take place gradually in the system of any of our Universities which do not at present exact a certain proficiency in physical science as a condition preliminary to obtaining a degree.

2ndly. That the number of Professors of Physical Science at the Universities shall be increased, where necessary; but that at all events, by a redistribution of subjects, or other arrangements, provision should be made for effectually teaching all the various branches of physical science.

3rdly. That Professors and Local Teachers shall be appointed to give lectures on Science in the chief provincial towns, for whose use philoso-

phical apparatus shall be provided; and that arrangements shall be made for testing by examination the proficiency of those who attend such lectures.

4thly. That the formation of Museums and Public Libraries in such towns, open to all classes, shall be encouraged and assisted in like manner as aid is now given to instruction in the principles of art; that all imposts shall by degrees be abolished that impede the diffusion of scientific knowledge; and such donations of national publications be made as above mentioned.

5thly. That more encouragement shall be given, by fellowships, increased salaries to Professors and other rewards, to the study of Physical Science.

6thly. That an alteration shall be made in the present system of bestowing pensions; some annuities in the nature of good-service pensions be granted; and additional aid be given to the prosecution, reduction, and publication of scientific researches.

7thly. That an appropriate building, in some central situation in London, shall be provided at the cost of the nation, in which the principal Scientific Societies may be located together.

8thly. That scientific offices shall be placed more nearly on a level, in respect to salary, with such other civil appointments as are an object of ambition to highly educated men; that the officers themselves shall be emancipated from all such interference as is calculated to obstruct the zealous performance of their duties; and that new scientific offices shall be created in some cases in which they are required.

9thly. That facilities shall be given for transmitting and receiving scientific publications to and from our colonies and foreign parts.

10thly, and lastly. That a Board of Science shall be constituted, composed partly of persons holding offices under the Crown, and partly of men of the highest eminence in science, which shall have the control and expenditure of the greater part at least of the public funds given for its advancement and encouragement, shall originate applications for pecuniary or other aid to science, and generally perform such functions as are above described, together with such others as Government or Parliament may think fit to impose upon it.

It will be observed, that the majority of the above desiderata ma be described rather as suggestions on behalf of national education than as privileges to be conferred on Science. Three of the propositions, however, the 6th, 7th, and 8th, involve the establishment of privileges and rewards not now enjoyed by those who make science either their profession or pursuit. Still it must be borne in mind, that the encouragement thereby afforded to the cultivation of science, and not the boon to the individual, is the principal object in view.

The 10th proposition, the establishment of the Board, is not advocated as a means of increasing privileges and emoluments, but as the best mode of accomplishing an important national object.

Of the value of Science no one surely can doubt who has received any mental training worthy of the name of education; and, notwithstanding any seeming indifference to an object of such vital importance, we believe that a feeling does pervade the community at large, that our country's welfare and even safety depend upon its due encouragement and fostering; and this is evidenced by the readiness with which the House of Commons accedes to demands, when made on its behalf. Owing, however, to the system which prevails in this country, of each successive Government striving to outvie its predecessors in popularity by the reduction of public burdens, there is a temptation sometimes to withhold grants which may swell the total outlay of departments in which reductions are contemplated. This it is more par-

ticularly which, in our opinion, renders the creation of the new Board, or some analogous measure, necessary.

Whatever may be the result of this appeal, or of any other measures which we may adopt in the discharge of our duty of watching over the interests of Science, we will never cease our endeavours to diffuse a sense of what is due to Science, and to those who make great personal sacrifices for the sake of a pursuit on which the happiness and welfare of mankind so materially depend.

14 July, 1855. WROTTESLEY, *Chairman.*

RECOMMENDATIONS ADOPTED BY THE GENERAL COMMITTEE AT THE GLASGOW MEETING IN SEPTEMBER 1855.

[When Committees are appointed, the Member first named is regarded as the Secretary of the Committee, except there be a specific nomination.]

Involving Grants of Money.

That the sum of £500 be placed at the disposal of the Council for maintaining the Establishment and providing for the continuance of Special Experiments at Kew.

That Professor Anderson, F.R.S., be requested to report on the compounds of Platinum and the allied metals with Ammonia; and that the sum of £10 be placed at his disposal for the purpose.

That Professor Hodges be requested to continue the inquiries necessary to complete the report on Flax Fibre; and that the £20 formerly voted to him be placed at his disposal for the purpose.

That a Committee, consisting of Professor Bunsen of Heidelberg, and Dr. H. E. Roscoe of London, be requested to continue their researches on the Laws of the Chemical Action of Light; and that the sum of £20 be placed at their disposal for the purpose.

That Mr. Mallet be requested to complete his experiments on Earthquake Waves; and that £40 be placed at his disposal for the purpose.

That Professors Phillips and Ramsay be requested to construct a vertical column of British Strata; and that the sum of £15 be placed at their disposal for the purpose.

That a Committee, consisting of Mr. Patterson, Mr. Hyndman and others, be requested to continue their Dredging Researches in the neighbourhood of Belfast; and that the sum of £10 be placed at their disposal for the purpose.

That the sum of £10 be placed at the disposal of the Council for the purpose of procuring a report on British Annelida.

That a Committee, consisting of Dr. Lankester, Professor Owen, Dr. Dickie, and Dr. Laycock, be requested to draw up Tables for the Registration of Periodic Phænomena; and that the sum of £10 be placed at their disposal for the purpose.

That a Committee, consisting of the Rev. C. P. Miles, M.D., Professor Balfour, Dr. Greville, and Mr. Eyton, be requested to report on the Dredging of the West Coast of Scotland; and that the sum of £10 be placed at their disposal for the purpose.

That Mr. R. Patterson, of Belfast, be requested to furnish Dredging Forms to the different Dredging Committees; and that the sum of £10 be placed at his disposal for the purpose.

That a Committee, consisting of Mr. T. C. Archer and Dr. Dickinson, be requested to draw up in a tabular form the Statistics of the Vegetable, Animal, and Mineral products imported into Liverpool; and that the sum of £10 be placed at their disposal for the purpose.

That a Committee, consisting of Mr. William Keddie and Mr. Michael Connal, be requested to draw up in a tabular form the Statistics of the Vegetable, Animal, and Mineral products imported into Glasgow; and that the sum of £10 be placed at their disposal for the purpose.

That a Committee, consisting of Sir William Jardine, Bart., Dr. Fleming, and Mr. Edmund Ashworth, be requested to report on the progress of experiments on the Propagation of Salmon; and that the sum of £10 be placed at their disposal for the purpose.

That a Committee, consisting of Professor Henslow and others, be requested to print 250 copies of their Report on the Typical Forms for Museums, for distribution; and that the sum of £10 be placed at their disposal for the purpose.

That Dr. Daubeny and a Committee be requested to continue their attention to the Vitality of Seeds; with £10 at their disposal for the purpose.

That Mr. William Fairbairn, C.E., be requested to continue his Report on the Strength of Iron Plates; and that a further grant of £10 be placed at his disposal for the purpose.

That Mr. James Thomson, C.E., be requested to report on the Measurement of Water by Weir Boards; and that the sum of £10 be placed at his disposal for the purpose.

That a Committee, consisting of Mr. Andrew Henderson, Major-General Chesney, Captain Sir Edward Belcher, Mr. James R. Napier, Mr. James Thomson, C.E., Mr. William Ramsay, C.E., Mr. Primrose, and Sir William Jardine, Bart., be requested to continue the investigation as to the statistics and condition of Life-Boats and Fishing-Boats; as to the principles on which such boats should be constructed; the essential conditions of their successful use; and the means of establishing them round the coasts: and that the sum of £5 be placed at their disposal for the purpose.

Involving Applications to Government or Public Institutions.

That a Committee be appointed, consisting of Mr. William Fairbairn, His Grace the Duke of Argyll, Captain Sir Edward Belcher, The Rev. Dr. Robinson, The Rev. Dr. Scoresby, Mr. Joseph Whitworth, Mr. James Beaumont Neilson, Mr. James Nasmyth, and Mr. W. J. Macquorn Rankine, to institute an inquiry into the best means of ascertaining those properties of Metals, and effects of different modes of treating them, which are of importance to the durability and efficiency of Artillery; and that the said Committee be empowered to communicate in the name of the Association with, and to request the assistance of, Her Majesty's Government.

That the Earl of Harrowby, His Grace the Duke of Argyll, Sir David Brewster, Colonel Sabine, Mr. Thomas Graham, Master of the Mint, Mr. William Fairbairn, and Mr. Thomas Webster, be a Committee for taking such steps as may be necessary to render the Patent system of this country, and the funds derived from inventors, more efficient and available for the reward of meritorious inventors, and the advancement of practical science.

That the thanks of the Association be presented to the Liverpool Compass Committee for their first report; that they be requested to continue researches so important, not only to the commercial interests of the nation, but to the progress of magnetic science; and that the Committee be recom-

mended to put themselves in communication with Her Majesty's Government, for the purpose of obtaining funds adequate to the effectual prosecution of the inquiry, in which application the British Association will gladly concur.

Report of the Parliamentary Committee.

1. That the thanks of the British Association be tendered to Lord Wrottesley and the Members of the Parliamentary Committee, for the vigilance and prudence with which they watch over the interests of Science in the Legislature.

2. That the Report of their proceedings since the last meeting more especially calls for the attentive consideration of the Association, as containing comprehensive views on the encouragement which Science requires of the Legislature, and suggestions of definite measures for augmenting the usefulness and amending the position of its cultivators and teachers.

3. That the British Association offer to the Parliamentary Committee its congratulations on the progress already made in this difficult and important question, and express its confident expectation that their labours will be ultimately rewarded by a satisfactory result.

4. That the British Association regard as a matter of immediate importance to the general interests of science, the seventh recommendation of the Parliamentary Committee, viz. That an appropriate building in the metropolis should be provided by the State, wherein the Scientific Societies may be placed in juxtaposition; and request the President to express respectfully to Her Majesty's Government their anxious hope that this recommendation may receive its early and favourable consideration.

That R. Stephenson, Esq., M.P., be elected in the Parliamentary Committee, instead of Sir R. H. Inglis, Bart., deceased.

That the British Association express their satisfaction at the establishment of the Meteorological Association in Scotland, and their willingness to afford them the assistance which can be yielded by the establishment at Kew.

That a letter to this effect be addressed to the Meteorological Association of Scotland by the General Secretary.

Reports and Researches.

That Mr. A. Cayley be requested to draw up a Report on the recent progress of Theoretical Dynamics for the next meeting of the British Association.

That Professor Phillips be requested to prepare a Report on Cleavage and Foliation in rocks; and on the theoretical explanations which have been proposed of these phænomena.

That a Committee, consisting of Professor Bennett, M.D., Professor Piazzi Smyth, and Professor George Wilson, be requested to report on the employment of M. Duboscq's Electric Lamps and Microscopic Apparatus for anatomical, physiological and other scientific purposes; and that they be recommended to make application to the Royal Society for assistance in procuring the necessary apparatus.

That Mr. J. F. Bateman, C.E., be requested to complete, in an engineering point of view, his Report on the supplying of Water to Towns.

That Mr. John Scott Russell be requested to proceed with his Report on Naval Architecture.

That Mr. William Fairbairn, C.E., be requested to continue his Report on Boiler Explosions.

That a Committee, consisting of Professor Smyth, the Rev. Dr. Robinson, Captain Sir Edward Belcher, Sir T. M. Brisbane, Professor Nichol, and Mr.

James Thomson, be requested to prepare a Report to the Council on the advantages of the telegraphic communication of Time-signals, and on the best method of accomplishing it.

That a Committee, consisting of Mr. W. Fairbairn, Dr. Neil Arnott, Mr. Henry Houldsworth, Mr. J. B. Neilson, Mr. C. T. Dunlop, Mr. James Robert Napier, Mr. James Aitken, Mr. Thomas Webster, Mr. W. J. M. Rankine, and Dr. John Taylor, be requested to prepare a Report on the subject of the Prevention of Smoke.

That a Committee, consisting of Mr. Andrew Henderson, Mr. J. R. Napier, Mr. John Wood, Mr. John Scott Russell, Mr. Allan Gilman, Mr. Charles Atherton, C.E., and Mr. James Peake, be appointed to consider the question of the Measurement of Ships for Tonnage.

A communication from Professor Henry, of Washington, having been read, containing a proposal for the publication of a Catalogue of Philosophical Memoirs scattered throughout the Transactions of Societies in Europe and America, with the offer of co-operation on the part of the Smithsonian Institution, to the extent of preparing and publishing, in accordance with the general plan which might be adopted by the British Association, a Catalogue of all the American Memoirs on Physical Science,—

The Committee approve of the suggestion, and recommend—

> That Mr. Cayley, Mr. Grant, and Professor Stokes, be appointed a Committee to consider the best system of arrangement, and to report thereon to the Council.

That the Rev. Dr. Whewell, the Dean of Ely, the Astronomer Royal, Sir J. F. W. Herschel, Colonel Sabine, Colonel Sykes, Mr. Gassiot, Professor Miller, and Mr. Hopkins, be appointed a Committee for considering the propriety of repeating the Balloon Experiments of 1852; and of applying to the Royal Society for the grant of the necessary funds; and that the Rev. Dr. Whewell be the Convener.

Having received from the Committee of Section A, a communication respecting the importance of having observations on the Sun's Atmosphere made at a considerable elevation above the sea, the General Committee resolved,—

> That a Committee, consisting of Mr. Piazzi Smyth, Astronomer Royal for Scotland, Professor Nichol, Mr. G. B. Airy, Astronomer Royal, Dr. Robinson, and Mr. W. Lassell, be appointed to consider of this proposition, and investigate the best means of accomplishing the object, and that they report to the next meeting of the Association.

That a Committee, consisting of Mr. James Thompson, C.E., and Mr. William Fairbairn, C.E., be requested to continue their investigations on the Friction of Discs in Water, and on Centrifugal Pumps.

That the Committee appointed last year, (viz. The Earl of Harrowby, Admiral Beechey, Mr. J. B. Yates, Mr. J. Boult, Sir R. I. Murchison, and Mr. Rennie,) to report upon the condition of the River Mersey, be reappointed, with the addition of Sir Philip Egerton, Bart., M.P., and Captain Henderson, and requested to continue the inquiry.

Communications to be printed among the Reports.

That the Communication by Mr. W. Whitehouse, on the rate of Electro-telegraphic Conduction, be printed entire in the next volume of Transactions.

That the Communication by Mr. J. Dobson, B.A., on the relation between Rotating Storms and Explosions in Collieries, be printed entire in the next volume of Transactions.

R. M. Milnes, Esq., M.P., D.C.L., gave notice of a motion to be proposed to the General Committee at the Meeting of the Association in 1856, as follows:—That the Section of the Association now named the Section of Statistics, be named the "Section of Economic Science and Statistics."

Synopsis of Grants of Money appropriated to Scientific Objects by the General Committee at the Glasgow Meeting in Sept. 1855, *with the name of the Member, who alone, or as the First of a Committee, is entitled to draw for the Money.*

	£	s.	d.
Kew Observatory.			
At the disposal of the Council for defraying expenses	500	0	0
Chemistry.			
ANDERSON, Prof.—Compounds of Platinum and other metals with Ammonia	10	0	0
HODGES, Prof.—Preparation of Flax	20	0	0
BUNSEN, Prof.—Chemical Action of Light	20	0	0
Geology.			
MALLET, R.—Earthquake Wave Experiments	40	0	0
PHILLIPS, Prof.—Section of British Strata	15	0	0
Zoology and Botany.			
PATTERSON, R.—Dredging near Belfast	10	0	0
The Council.—British Annelida	10	0	0
LANKESTER, Dr.—Periodical Phænomena	10	0	0
MILES, Rev. C. P.—Dredging on the West Coast of Scotland.	10	0	0
PATTERSON, R.—Dredging Forms	10	0	0
ARCHER, T. C.—Natural products imported into Liverpool ..	10	0	0
KEDDIE, W.—Natural Products imported into Glasgow......	10	0	0
JARDINE, Sir W.—Propagation of Salmon	10	0	0
HENSLOW, Prof.—Typical Forms for Museums	10	0	0
DAUBENY, Dr.—Vitality of Seeds..........................	10	0	0
Mechanics.			
FAIRBAIRN, W.—Strength of Iron Plates	10	0	0
THOMSON, James.—Measurement of Water by Weir-boards ..	10	0	0
HENDERSON, Andrew.—Life-Boats	5	0	0
Grants....	£730	0	0

General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain Gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£434	14	0
1837.			
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	89	5	3
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£918	14	6
1838.			
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (Strength of)	60	0	0
Animal and Vegetable Substances (Preservation of)	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Subterranean Temperature	8	6	0
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
Thermometers	16	4	0
	£956	12	2
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	7
Cast Iron Experiments	100	0	0
Railway Constants	28	7	2
Land and Sea Level	274	1	4
Steam-vessels' Engines	100	0	0
Stars in Histoire Céleste	331	18	6
Stars in Lacaille	11	0	0
Stars in R.A.S. Catalogue	6	16	6
Animal Secretions	10	10	0
Steam-engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phænomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4
1841.			
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0

	£	s.	d.
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	0
Railway Sections	38	1	6
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East coast of Scotland	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment in Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3

	£	s.	d.
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes ...1842	23	11	10
Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas ...1842	100	0	0
Geographical Distributions of Marine Zoology ...1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	3
Experiments on the Vitality of Seeds ...1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument, 1842	10	3	6
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Cooperation	16	16	8
Meteorological Instruments at Edinburgh	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment in Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura ...1843	10	0	0
Vitality of Seeds ...1843	2	0	7
Vitality of Seeds ...1844	7	0	0
Marine Zoology of Cornwall	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Earthquake Shocks ...1843	15	14	8
	£830	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars ...1844	211	15	0
Fossil Fishes of the London Clay	100	0	0
Computation of the Gaussian Constants for 1839	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds ...1844	2	15	10
Vitality of Seeds ...1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain	10	0	0
Exotic Anoplura ...1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons ...1844	8	19	3
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality at York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1839	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4

1848.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogues of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8

1849.

	£	s.	d.
Electrical Observations at Kew Observatory	50	0	0
Maintaining Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phænomena	10	0	0
Bill on account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0

	£	s.	d.
Periodical Phænomena	15	0	0
Meteorological Instrument, Azores	25	0	0
	£345	18	0

1851.	£	s.	d.
Maintaining the Establishment at Kew Observatory (includes part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phænomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

1853.	£	s.	d.
Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0

1854.	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phænomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7

1855.	£	s.	d.
Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4

Extracts from Resolutions of the General Committee.

Committees and individuals, to whom grants of money for scientific purposes have been entrusted, are required to present to each following meeting of the Association a Report of the progress which has been made; with a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of pecuniary aid for scientific purposes from the funds of the Association expire at the ensuing meeting, unless it shall appear by a Report that the Recommendations have been acted on, or a continuation of them be ordered by the General Committee.

In each Committee, the Member first named is the person entitled to call on the Treasurer, John Taylor, Esq., 6 Queen Street Place, Upper Thames Street, London, for such portion of the sum granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the Members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named shall be deemed to include, as a part of the amount, the specified balance which may remain unpaid on the former grant for the same object.

General Meetings.

On Wednesday, Sept. 12th, at 8 P.M., in the City Hall, the Earl of Harrowby, F.R.S., resigned the office of President to the Duke of Argyll, F.R.S., who took the Chair at the General Meeting, and delivered an Address, for which see page lxxiii.

On Thursday, Sept. 13th, a Soirée took place in the M'Lellan Rooms.

On Friday, Sept. 14th, at 8 P.M., in the City Hall, W. B. Carpenter, M.D., F.R.S., delivered a Discourse on the Characters of Species.

On Saturday, Sept. 15th, a Soirée took place in the M'Lellan Rooms.

On Monday, Sept. 17th, at 8 P.M., in the City Hall, Lieut.-Col. Rawlinson, C.B., delivered a Discourse on Assyrian and Babylonian Antiquities and Ethnology.

On Tuesday, Sept. 18th, the President's Dinner took place at ½ past 5 P.M., in the City Hall.

On Wednesday, Sept. 19th, at 3 P.M., the concluding General Meeting of the Association was held in the City Hall, when the Proceedings of the General Committee, and the Grants of Money for scientific purposes, were explained to the Members.

The Meeting was then adjourned to Cheltenham *.

* The Meeting is appointed to take place on Wednesday, the 6th of August, 1856.

ADDRESS

OF

THE DUKE OF ARGYLL, F.R.S.

Gentlemen of the British Association,

I know, Gentlemen, that the duty of presiding over this Meeting of the British Association for the Advancement of Science, has been assigned to me mainly in consequence of my local connexion with the district and City in which we are now assembled. It cannot therefore be departing from the special duty of that position, if I address you in the first place as one of those who are receiving the honour of your visit. I am sure I cannot express in terms too warm the feelings of this great community. It would be strange indeed if Glasgow did not hold out to you a cordial reception. Here, if anywhere, we have reason to honour Science, and to welcome the men whose lives are devoted to its pursuit. The West of Scotland has itself contributed not a few illustrious names to the number of those who have enlarged the boundaries of knowledge, or have given fruitful application to principles already known. I need not dwell on the fact that it was in this valley of the Clyde that the patient genius of Watt perfected the mechanism which first gave complete control over the powers of steam; and that it was on these waters too that those powers were first applied in a manner which has given new wings to commerce, and is now affecting not less decisively the terrible operations of war. These are but single examples, more striking and palpable than others, of the dependence of the Arts upon the advance of Science. This, however, is a dependence which I am sure the citizens of Glasgow would be the first to acknowledge, and which no doubt, with them as with all men, must be an important element in the value which they set upon physical research. But I am sure I should deeply wrong the intelligence of the people of Glasgow, if I were to represent them as measuring the value of science by no other standard than its immediate applicability to commercial purposes. They seek to honour science for its own sake, and to encourage the desire of knowledge as in itself one of the noblest instincts of our nature.

It is my duty also, Gentlemen, to speak on behalf of a special body—one of which Glasgow has so much reason to be proud—I mean its ancient and venerable University. If the mechanical arts owe to this district of Scotland the greatest impulse they have ever yet received, it is not less true that our knowledge of the laws which regulate the pursuits of industry, and determine the distribution of the "Wealth of Nations," has been almost founded on the

researches of one whose name is indissolubly associated with this seat of learning. Here again we have an illustrious example of the mutual relations between science and politics in its best and highest definition. But indeed our convictions are independent of such examples. It is impossible to appreciate too highly the influence which science is evidently destined to have on the prospects of education, and we look for the time when its methods, as well as its results, will form the subject of teaching, not only as partially it has long done in our Colleges, but also in the humblest of our schools. I feel it to be no small privilege arising out of the Academical Office which this year I have the honour of holding, to be able to assure you on behalf of the University of Glasgow of the deep interest with which we regard your visit, and of our high appreciation of the ends which it is your object to promote.

It is now fifteen years since the last Meeting of the British Association here. There are probably few even annual meetings of any considerable body of men, which are not marked by some melancholy recollections. Still more must this be the case after the lapse of so long an interval,—one which measures, as is usually reckoned, full half a generation in the life of man. Among the many vacancies in your ranks which that period has occasioned there are some which, from local association or from other causes, are naturally impressed more deeply on the mind than others. I am sure that one venerable name will rise to the memory of all who took any interest in the proceedings of 1840;—of one whose early tastes for natural science had only yielded before his devotion to a yet higher service; but whose powerful mind still sought to found all his efforts in the cause of religion and humanity on obedience to the eternal laws, which are as sure and steady in their operation over the minds of men, and over the progress of society, as are other laws over the subjects of material change. Who can forget the zeal and more than youthful eagerness with which Dr. Chalmers entered into the discussions of the Statistical section; and how he saw in those discussions the means of spreading the knowledge of principles which are of vital interest to the welfare of the State?

But that name, though the lapse of years has not carried it beyond the region of regret, is one with which we have at least become familiar as belonging to the number of the departed great. Such is not the case with other vacancies, and especially with one which is still affecting us with almost bewildered sorrow, and an abiding sense of irreparable loss. Who shall take up the torch which has fallen from the hand of Edward Forbes? Who shall hold it as he held it to those dark places in the History of Life which Science is striving, perhaps in vain, to penetrate, but which seemed already opening their treasures to his fine and advancing genius?

But whilst sad recollections are thus forced upon us as regards the life of individual men, we have every reason to be satisfied with the inheritance they have left. Many labourers are gone, but the cause in which they laboured has been steadily gaining ground. Long as fifteen years may be as a period in human life, it is generally but a fraction in the history of mental progress. Yet since the last Meeting of the British Association here, I am greatly mistaken if we cannot mark great strides in the advance of science. I wish, Gentlemen, you had a President more competent than I am to chronicle that advance, and direct the retrospect to a practical and useful end. There are, however, some features so remarkable that I cannot omit referring to them, as well calculated to raise our hopes and stimulate our exertions. In that science which is the oldest and most venerable of all, I mean Astronomy, if there had been nothing else to mark the progress of discovery, the construction and application of Lord Rosse's Great Reflector

would have been enough to constitute an important epoch. Its systematic operations may be said to be still only in the first stages of their progress; yet already how often do we see reference had to the mysterious revelations it has made in discussions on the principles of that science, and in not a few of the speculations to which they are giving birth! My distinguished friend Sir D. Brewster, in his recent Life of Newton, has designated that telescope as "one of the most wonderful combinations of art and science which the world has yet seen." All who are interested in the devotion of abilities, of means and of leisure to the noblest pursuits, must earnestly wish to see Lord Rosse rewarded by that which he will value most, the steady progress of discovery. It must always be remembered, however, that Astronomy is a science of which hitherto at least it might almost be said that one great genius had left us no more worlds to conquer; that is to say, he carried our knowledge at a bound to one grand, and apparently universal law, to which all worlds were subject, and of which every new discovery had been but an additional illustration. The reign of that law, whether universal or not, was at least so wide, that we had never pierced beyond the boundary of its vast domain. For the first time since the days of Newton a suspicion has arisen in the minds of astronomers that we have passed into the reign of other laws, and that the nebular phænomena revealed to us by Lord Rosse's telescope must be governed by forces different from those of which we have any knowledge. Whether this opinion be or be not well founded—whether it be or be not probable that our limited command over time and space can ever yield to our research any other law of interest or importance comparable with that which has already been determined—still, inside that vast horizon there are fillings-in and fillings-up which will ever furnish infinite reward to labour. Of these not a few have been secured since our last meeting here. Besides the patient work of our professed Astronomers, and the good service rendered by such men as Mr. Lassell and Mr. Nasmyth, who have so well relieved the business of commercial industry by their devotion to the pursuits of science, we have had one event so remarkable that in the whole history of Astronomy it stands alone. If in looking at the wonderful objects revealed to us in Lord Rosse's telescope, we turn instinctively sometimes from the thing shown to the thing which shows—from the Spiral Nebulæ to the knowledge and resources which have collected their feeble light, and brought their mysterious forms under the cognizance of the human eye, how much more curiously do we turn from the single planet Neptune, to that other instrument which has *felt*, as it were, and found its obscure and distant orbit! So long as our species remains, that body will be associated with one of the most glorious proofs ever given of the reach of the human intellect;—of the sweep and certainty of that noble science which now honours with enduring memory the twin names of Adams and Leverrier.

In Geology, the youngest, but not the least vigorous of the sciences, every year has been adding to the breadth of its foundation—to the depth and meaning of its results. Probably no science has ever advanced with more rapid steps. In 1840 the then recent publication of the "Silurian System" had just established those landmarks of the Palæozoic world which all subsequent discovery has only tended to confirm. The great horizons which were first defined by the labours of Murchison and Sedgwick have since disclosed the same phænomena which they so accurately described, in every quarter of the globe; and the generalizations founded thereupon have been definitely established. The same period has sufficed, partly by the labours of the same distinguished men, to clear up the relative position of the strata which represent the closing epochs of ancient life, and those which form the base of the

secondary age. But above all, the last few years have seen immense progress made in our knowledge of that vast series of deposits which usher in the dawn of existing forms, and carry us on to those changes, which, though the most recent, are not the least obscure of any which have affected the surface of the globe. The investigations of Edward Forbes on the laws which determine the conditions of Marine Zoology, have supplied us with data altogether new on some of the highest conclusions of the science; whilst his profound speculations on the centres of creation and areas of distribution have pointed out paths of inquiry which are themselves of inexhaustible interest, and hold out the promise of great results. Another branch of investigation, which, if not entirely new, is at least pursued on a new system, and with new resources, has been opened up in Dynamical Geology by the learning and ingenuity of Mr. Hopkins; whilst the thorough elucidation of the conditions of Glacier Motion, which we owe to Professor James Forbes of Edinburgh, has given us clear and definite ideas on one, and that not the least important of the agents in Geological change. The observations accumulated during the recent Arctic voyages have materially added to our knowledge of the operation of the same agency under different conditions—conditions which we know must once have extended widely over the firths and estuaries near where we are now assembled—leaving behind them those enduring records of the Glacial epoch which were first explored by my friend Mr. Smith of Jordan-hill. We owe many important observations on the same phænomena, and on the various changes of sea-level, to Mr. Robert Chambers. And if the thanks of Science are due to those who advance her interests, both directly by adding to her store of facts, or of her discovered laws; and also indirectly by investing them with popular interest, and thus enlarging the circle of observers, we must mention with special gratitude the classical works of Mr. Hugh Miller; and those writings of Sir Charles Lyell, which his indefatigable industry is ever bringing up abreast with the progress of discovery—a progress stimulated in no small degree by his own exertions,—and which are alike remarkable for completeness of knowledge, for fertility of suggestion, and for sound philosophical reasoning. I think we cannot mistake the general tendency of Geological research, whether Stratigraphical or Zoological. It has been to prolong periods which had been considered short; to divide others which were classed together; to fill up spaces which were imagined blank, and to connect more and more in one unbroken chain the course of physical change and the progress of organic life.

We pass from geology by a natural transition to another science which stands to it in close alliance. If all our most sure conclusions respecting the superficial covering of the globe have been founded on the classification of its animal remains, it is not less true that our knowledge and understanding of organic structure have been infinitely extended by the means which geology has afforded of studying that structure in relation to its history in past time. In the hands of our great countryman, Professor Owen, Physiology has assumed a new rank in science, leading us up to the very threshold of the deepest mysteries of Nature. If the last few years had been marked by no other event in the advancement of science, there would have been enough to signalise them in the publication of his treatise on the "Homologies of the Vertebrate Skeleton:" and we may recollect with pride the fact of that high argument having been first opened at a Meeting of the British Association.

A sad interest, indeed, attaches, in one direction at least, to the progress of our knowledge in Geography. All serious doubt seems to have closed now over the grave of Franklin. Even in a year during which war has been

claiming the noblest victims by thousands and tens of thousands, it would ill become this Association not to mark with an expression of our sorrow and admiration the self-sacrifice of that gallant band which has perished in the cause of science. But their devotion has been emulated, under a still higher stimulus, in the more successful career of others: and at last in the discovery of the North-West Passage (still so-called in spite of its having been found impassable), the courage and endurance of Captain M^cClure and his associates have ascertained with certainty a most remarkable fact in the physical conformation of the globe. Results of still larger, and certainly of more immediate interest are being arrived at by the rapid march of African exploration,—not, surely, before the time. Every part of the *circumference* of that vast continent has been either known or accessible to us for centuries. On its soil have flourished some of the most ancient and famous monarchies; and one of its great valleys is the fatherland of science. Yet up to comparatively recent times our horizon there has been bounded by the same sands or mountains which bounded the knowledge of antiquity, and we had almost as little acquaintance with its interior as had the Tyrian merchant when his eye rested of old on the Peaks of Atlas. Nothing but familiarity with the fact could have reconciled us to the ignorance in which we have so long remained of one of the largest and most interesting regions of the world. That ignorance is at last being cleared away; and the exertions of many individuals, amongst whom the names of Mr. Galton, of Mr. Anderson, Dr. Livingston, Dr. Baikie and Dr. Barth, stand conspicuous, have contributed results of the deepest interest and importance. No man who values science can fail to appreciate the extension of our knowledge respecting geography even where, as in the Arctic regions, that knowledge is pursued simply for its own sake. But it becomes invested with tenfold interest when it brings with it the largest influence on the destinies of millions of the human race; and adds, as we may confidently hope it will ultimately do in the case of Africa, an inexhaustible field for manufacturing and commercial enterprise.

In connexion with the diffusion of geographical knowledge I cannot omit to mention the magnificent publications of Mr. Alexander Keith Johnston of Edinburgh, in his Atlas of Physical Geography. It is seldom that such a mass of information has been presented in a form so beautiful and attractive; or one which tends so much to place the study of geography on a truly scientific basis—that is to say, on the basis of its relation to the other natural sciences, and those grand cosmical views of terrestrial phænomena which have found their most distinguished interpreter in Baron Humboldt.

The kindred science of Ethnology has received of late years great development; not only by its increasing store of facts, but by the more scientific use which is being made of facts which have been long familiar. The investigation of the laws which regulate the growth of language, promise to cast the most important lights on the history of our race; but the conclusions to which that investigation may lead are still matters of keen and anxious controversy, and are exposed to all that suspicion which has been directed against almost every science at some stage or other of its growth; and which, we must allow, every science has, at some stage or other, justified by hasty generalization and premature deduction.

Of all the sciences Chemistry is that which least requires to have its triumphs recorded here. The immediate applicability of so many of its results to the useful arts has secured for it the watchful interest of the world; and every day is adding some new proof of its inexhaustible fertility. There is one department of inquiry, and that perhaps the most interesting of

all, I mean Organic Chemistry, which has received an especial impulse during the last few years, an impulse mainly due to the genius of one distinguished man whom we have the honour of numbering among our guests upon this occasion. I think Baron Liebig will find in Scotland that kind of welcome which a man of science values most,—a readiness to profit by his instructions, and an enlightened appreciation among the farmers of the country of the practical value of studying in their husbandry the laws which have been revealed by his research. I am reminded, through the kindness of Dr. Lyon Playfair, of some facts which give yet a more special interest to this subject in connexion with our meeting here. It was to the British Association at Glasgow in 1840 that Baron Liebig first communicated his work on the Application of Chemistry to Vegetable Physiology. The philosophical explanation there given of the principles of manuring and cropping gave an immediate impulse to agriculture, and directed attention to the manures which are valuable for their ammonia and mineral ingredients; and especially to guano, of which in 1840 only a few specimens had appeared in this country. The consequence was that in the next year, 1841, no less than 2881 tons were imported; and during the succeeding years the total quantity imported into this country has exceeded the enormous amount of 1,500,000 tons. Nor has this been all: Chemistry has come in with her aid to do the work of Nature, and as the supply of guano becomes exhausted, limited as its production must be to a few rainless regions of the world, the importance of artificial mineral manures will increase. Already considerable capital is invested in the manufacture of superphosphates of lime, formed by the solution of bones in sulphuric acid, the use of which was first recommended at the last Glasgow Meeting. Of these artificial manures not less than 60,000 tons are annually sold in England alone; and it is a curious example of the endless interchange of services between the various sciences that Geology has contributed her quota to the same important end; and the exuviæ and bones of extinct animals, found in a fossil state, are now, to the extent of from 12,000 to 15,000 tons, used to supply annually the same fertilizing materials to the soil. The exertions of Professor Daubeny of Oxford on the same important subject, and the continued attention which he has devoted to it, have done much for the cause of agricultural chemistry in England; whilst the thanks both of practical and of scientific men are due to Dr. Lyon Playfair, and Professor Gregory of Edinburgh, for those admirable translations of Baron Liebig's works, which have rendered them accessible to every English reader; and have thereby had no unimportant influence in extending the knowledge of the laws affecting both vegetable and animal physiology.

I am indebted to the same quarter for the mention of one remarkable instance of the manner in which—to use Dr. Playfair's words—"the overflowings of Abstract Science pass into and fertilize the field of Industry." One of the newest and most obscure subjects of chemical research has been the discovery of certain conditions under which bodies, like in their composition, are nevertheless endowed with unlike properties, and thereby become convertible to new purposes. It is in the application of this principle that a gentleman of this city, Mr. James Young, has succeeded in obtaining the illuminating principle of coal gas either in a solid or liquid state; and it has proved to be a substance of immense value for the lubrication of machinery, vast quantities of it being now manufactured and sold for that purpose.

I hardly know whether it is strictly in connexion with the advance of chemical knowledge that I ought to remind you of one great discovery made

long since we last assembled here;—I refer to the discovery of the effects of chloroform on the animal system; one which claims for my friend Dr. Simpson of Edinburgh a high place indeed among the benefactors of mankind. Chloroform as a mere chemical composition had indeed been known before, and had been made the subject of elaborate research by the distinguished French chemist, M. Dumas, whom we have here the honour of receiving as a guest. But the discovery of its application is not the less a triumph of science, and of the best and highest scientific faculties. Seldom indeed has that disposition of mind which is ever ready to receive a chance suggestion, and to pursue it believing what great things we have yet to learn, been crowned with a more brilliant and direct reward.

It marks the growing sense entertained of the value of Statistical research, that, during the late session of Parliament, a committee of the House of Lords sat for a considerable time on the best means of securing a complete system of Agricultural Returns. We owe much in this matter to the exertions of the Highland Society of Scotland, and, as has been specially recorded by the committee, to the zeal and activity of their able secretary, Mr. Hall Maxwell. We owe not less, also, to the high intelligence of the farmers of Scotland generally, who have rendered every assistance in their power, and that with a willingness which can only arise from an enlightened appreciation of the great objects to be gained by the inquiry.

No one has rendered more important service to Statistical science, in one of its most interesting departments, than the able Chamberlain of this city, Dr. Strang. His periodical Reports on the Growth and Progress of Glasgow are among the most curious and useful records of the kind which have been published in any part of the United Kingdom. I need hardly say that they supply materials for much reflection on many questions connected with the social welfare of the people. I believe Dr. Strang has lately visited Paris, with a view to communicate to this Meeting of the Association various facts connected with the great improvements which are in the course of progress in that city. Should his investigations cast any light on the best means of improving the dwellings of the labouring classes in the great centres of population, and on the possibility of doing so on a large scale, by public authority, he will have rendered no small service to his country in a matter of vital interest and of much difficulty.

Closely connected with the subject of Statistics, as applied to Agricultural returns, I am happy to say that, mainly owing to the exertions of Sir J. Forbes of Fettercairn, and of Mr. Milne Home, a Meteorological Society for Scotland has been established, warmly seconded by the Highland Society. The wonderful results on a great scale which have been obtained in this department of science by Lieut. Maury of the United States, give us ground to hope that even on the small areas of individual countries, where of course, from the crossing of local influences, the general result is infinitely complicated, some approach may be made towards ascertaining the laws which regulate the seasons.

The admirable agency which is now afforded by the Kew Committee of this Association, for the verification of instruments, and by the new meteorological department of the Board of Trade under Capt. FitzRoy, for the reduction of local observations, will, I trust, be taken advantage of by the new Scottish Society. I cannot help congratulating the Association on the position which has been secured by science in connexion with both of these establishments. The thanks of the commercial as well as of the scientific world are due to Colonel Sabine and the other members of the Kew Committee, whose assistance is now highly appreciated by practical men, and

eagerly sought for by the best instrument-makers; whilst Capt. FitzRoy's office and duties are in themselves an acknowledgement of no small importance of the public value of systematic observation.

The increasing employment of iron in ship-building has brought into corresponding notice the uncertainty which attends the action of the compass on board vessels of that construction. This important and intricate subject has been treated of by Mr. Archibald Smith of Jordan Hill, with all the resources of his high mathematical and scientific attainments, in publications which have appeared under the sanction and with the recommendation of the Admiralty. It will not fail to interest this great commercial city, whose freights are on every sea, that this question was taken up at the last Liverpool Meeting by Dr. Scoresby, that it has continued to occupy his close attention, and that he intends to communicate to this Meeting of the Association some of the valuable results of his investigations.

Feeling deeply, as I do, my own inability to give anything like an adequate sketch—even in outline—of the progress of science during the last few years, I remember at the same time with some satisfaction, that it is less the business of this Association to boast of the achievements which have already been effected, than to devise means of facilitating those which are yet to come. You have appointed a Parliamentary Committee for the consideration of one important branch of this inquiry. We shall doubtless hear from my noble friend Lord Wrottesley those recommendations which have been the result of its recent labours, and which will be found to owe much to his enlightened zeal, to his great knowledge and his sound judgment. In the meantime, I trust I may be allowed to make a few general observations on what appear to me to be some of the best means of promoting in this country the advancement of physical science.

It will readily be understood, that, in referring for a moment here to the aid which may be afforded by the State to the advancement of science, I divest myself entirely of any official character other than that which belongs to me as your President, and that I seek to give expression to my own opinions only.

I am not one of those who are disposed to look to public authority as the primary or the best supporter of abstract science. In the main it must depend for its advancement on its own inexhaustible attractions,—on the delight which it affords us to study the constitution of the world around us, and to endeavour to understand, though it be but darkly, how the reins of its government are held. Nor am I disposed to indulge in any complaint on a matter which has lately attracted some attention among scientific men. In a great manufacturing country like ours, the disposition of whose people is eminently practical, it is perfectly natural that greater attention should be bestowed on the arts than on the abstract sciences. This, indeed, is but adhering to what has been hitherto at least the natural and historical order of precedence; for it is a just observation of Professor Whewell, in his lecture on the results of the Great Exhibition of 1851, that practice has generally gone before theory—results have been arrived at, before the laws on which they depend had been defined or understood. Art, in short, has preceded science. But it is equally important to observe, that in recent times this order has been in numberless instances reversed. Abstract science has gone ahead of the arts, and the conduct of the workshop is now perpetually receiving its direction from the experiments of the laboratory. Perhaps the most wonderful discovery of modern days—that of the Electric Telegraph—was thought out and perfected, so far as its principle was concerned, in the closet and the lecture-room, and

flashed ready-made on the astonishment of the world. In chemistry, the lead taken by abstract science in reacting on the arts is manifest and constant; and in a greater or less degree the same result is appearing in connexion with every branch of physical research. The interest, therefore, of the State, even if it be considered merely in this economic point of view, in the encouragement of abstract science, is obvious and immediate. And there is this additional motive to be remembered: the moment any result of science becomes applicable to the arts, the unfailing enterprise of the commercial and manufacturing classes takes it up and exhausts every resource of capital and of skill in giving to that application the largest possible development. But so long as science is still purely abstract, it has often to be prosecuted with slender resources, and specially requires fostering care and a helping hand. But I rejoice to believe that the conviction of this truth is sensibly gaining ground. The foundation of the geological museums both in England and in Scotland, and the carrying out of a complete geological, concurrently with a geographical survey, by public authority and at the public expense, were great steps in the right direction. Another such step was the investment of £1000 annually in aiding experimental research, through the agency of the Royal Society, which undertook the trouble of its special allocation. It is the intention of my noble friend, Lord Palmerston, to bring the principle of some expenditure in this direction specially under the notice of Parliament for the future; and it is worthy of remark, as illustrating how far a small sum may go in aid of abstract science, and how cheaply the largest and most fruitful results may thereby be attained, that, as I have been informed on very high authority, this apparently trivial sum has been felt as a most important help in numberless instances, sometimes in the conduct of experiments, sometimes in the publication of their results, and sometimes in securing accurate artistic delineations.

The relations now established between the Board of Trade and various branches of scientific investigation are such as lay the foundation for further progress in the same direction. I am happy to say that, in connexion with the new national museum which is being organized for Scotland, there is to be a special branch devoted to the industrial applications of science; and that a new Professorship—one which has long existed in almost all the continental universities—that of Technology—has just been instituted by the Government. I am not less happy in being able to announce that to that chair Dr. George Wilson has been appointed. The writings which we owe to the pen of Dr. Wilson, and especially his beautiful Memoirs of Cavendish, and of Dr. Reid, are among the happiest productions of the Literature of Science.

I trust also that the aid of the State may be secured in providing a house and home for the scientific bodies in the metropolis. I am disposed to agree with those who attach no small importance to this consummation. When the Royal Society alone adequately represented all or nearly all who were engaged in physical science, that great body fulfilled all the necessary conditions of a scientific council. But now, when almost every separate division of science has a separate society of its own, it has become almost indispensable that some new arrangement should be come to, in order that abstract science may have that degree of organization without which its interests will never receive the public attention which they ought to have.

The influence, if not the authority of the State, may also, I think, be most beneficially exerted on behalf of Science, through the educational rules and principles of administration of the Privy Council. But the Committee of Council, in the adoption of those rules, is necessarily governed to a certain extent by the feelings and opinions of the various churches and bodies which

are the primary supporters of our existing educational system. In the last Report of the Council of the Geographical Society, they announce a communication from the Committee of Privy Council, requesting the Society to appoint an Examiner in Geography, to be associated with other examiners on other branches of education. It may be well worthy of consideration, whether the same expedient might not be usefully adopted in reference to other branches of science, which have hitherto formed a less admitted part of ordinary instruction.

And this, Gentlemen, brings me to say, that the Advancement of Science depends, above all things, on securing for it a better and more acknowledged place in the education of the young. There are many signs that the time is coming when our wishes in this respect will be fulfilled. They would be fulfilled, perhaps, still more rapidly, but for the operation of obstructing causes, some of which we should do well to notice. How often do we find it assumed, that those who urge the claims of Science are desirous of depreciating some one or more of the older and more sacred branches of education! In respect to elementary schools we are generally opposed, as aiming at the displacement of religious teaching; whilst in respect to the higher schools and colleges, the cudgels are taken up in behalf of classical attainments. A remarkable example of the influence of these feelings will be found in a speech delivered by Lord Lyndhurst during the late session of Parliament. With all the power of his dignified and commanding eloquence he asserted the right of the elder studies to their time-honoured pre-eminence; and in the keen pursuit of this argument even he was almost tempted to speak in a tone of some depreciation of those noble pursuits in which the University of which he is a distinguished ornament has won no small portion of her fame. But surely no enlightened friend of the Natural Sciences would seek to challenge this imaginary competition. Perhaps, indeed, like other zealous advocates, we may have sometimes overstrained our language, and have thereby given such vantage-ground to prejudice, that it has been enabled to assume the form of just objection. We cannot too earnestly disclaim the idea that the knowledge of physical laws can ever of itself form the groundwork of any active influence in morals or religion. Any such idea would only betray our ignorance of some of the deepest principles of our nature. But this does not affect the estimate which we may justly put on an early training in the principles of physical research. That estimate may be not the less a high one, because it does not assign to science what belongs to other things.

There is one aspect in which we do not require to plead the cause of science as an element in education, and on that, therefore, I shall not dwell. I mean that in which certain applied sciences are recognized as the essential bases of professional training: as, for example, when the engineer is trained in the principles of mechanics and hydrostatics, or the physician in those of chemistry. Of course, with every new application of the sciences to the arts of life this direct influence will extend. But what we desire, and ought to aim at, is something more. It is, that abstract science, without special reference to its departmental application, should be more recognized as an essential element in every liberal education. We desire this on two grounds mainly; first, that it will contribute more than anything else to the further advancement of science itself; and, secondly, because we believe that it would be an instrument of vital benefit in the culture and strengthening of the mental powers.

But, as regards both these great objects, we must remember that much will depend on the manner in which elementary instruction in science is con-

ducted; on the conception, in fact, which we entertain of what science really is. Nothing can be easier than so to teach science as to feed every mental vice or weakness which obstructs the progress of knowledge, or blinds men to every evidence of new truths, in self-satisfied contemplation of the few they have already ascertained. May we not illustrate this by the effect which has not seldom been produced by the scientific education of professions? It is true, indeed, that professional men have often enlarged the field of science by the discovery of new and important truths. Some of the strongest-armed pioneers of science have been of this class. But how have their discoveries been too often received by their professional brethren? How many of them have been assailed by every weapon in the extensive armoury of prejudice and bigotry! How many of them have had their name recognized only after it had been written on the grave! and over whom we might well repeat the noble lines—

> . . . . . Now thy brows are cold
> We see thee, what thou art, and know
> Thy likeness to the wise below,
> Thy kindred with the great of old.

What we want in the teaching of the young, is, not so much the mere results, as the *methods*, and, above all, the *history* of science. How, and by what steps it has advanced; with what large admixture of error every new truth has been at first surrounded; by what patient watchings and careful reasonings; by what chance suggestions and happy thoughts; by what docility of mind, and faith in the fullness of Nature's meanings; in short, by what kinds of power and virtue, the great men, aye, and the lesser men of science have each contributed their quota to her progress; this is what we ought to teach, if we desire to see education well conducted to the great ends in view. It is not merely for the sake of investing the abstractions of science with something of a living and human interest, that we should recall and revive these passages in her history: nor is it merely to impress her results better on the memory, as we fill up from biographies and other sources of information, the meagre page of the general historian. It is for something more than this. It is both that they may be more encouraged to observe nature, and that they may better understand how to do so with effect. It is that they may cultivate that temper of mind to which she most loves to reveal her secrets. And as regards those whose own opportunities of observation may be small, it is that they may better appreciate the labours of others; and may be enabled to recognize, in the midst, perhaps, of much extravagance, the tokens of real genius, and in the midst of much error the golden sands of truth.

It is one of the many observations of Sir C. Lyell which have a much wider application than that to which they were specially directed, that the mistake of looking too exclusively to the grand results of geological change, and of referring them too readily to sudden agencies of tremendous activity and power, tended to check the advance of that science, by discouraging habits of watchfulness over those operations which are contemporary with ourselves, and the secret of whose power is to be found in the lapse of time. An effect precisely analogous is produced on the progress of science as a whole by a similar method of regarding it. And even when the history of that progress is attended to at all, there is a natural disposition to look back to a few great names among the number of its chief promoters, as Beings who, by dint only of some unapproachable superiority of intellect, have taught us all we know. It is true, indeed, there have been a few such men; just as there have been periods of sudden geological operations, which have

upheaved at once stupendous and enduring monuments. But even in respect to those great men, it will often be found that at least one great secret of their power has lain in virtues which might be more common than unfortunately they are found to be. That openness and simplicity of mind which is ever ready to entertain a new idea, and not the less willing that it may be suggested by some common and familiar thing, is one of the surest accompaniments of genius. But it is clearly separable from extraordinary intellectual power, although, where both are found together, the great results produced are too often attributed to the more brilliant faculty alone. Professor Whewell, in his most interesting History of the Inductive Sciences, whilst deprecating the degree of attention which has been paid to the well-known story respecting the origin of Newton's thoughts on gravitation, has nevertheless stated, with his usual clearness and precision, the essential truth which the traditions of science have done well to cherish. Those who have been competent to judge of the calibre of Newton's mind, of its powers of pure abstract reasoning, have with one voice assigned it the highest place in the records of human intellect. Doubtless, it was those powers which enabled him to *prove* what otherwise would have remained conjecture. But it is not the less important to observe, that the suggestion on which these powers were called to work was one eminently characteristic of a mind where simplicity and greatness were indeed synonymous. That the celestial motions, about which so many wonderful facts were then already known, and which had been referred to so many mysterious and imaginary forces, should be indeed identical in kind with the motions which took place close beside him, and that the same rules should be applicable to each, this was an idea in which, to use Dr. Whewell's words, "Newton had no forerunner." We do not need to compare the relative importance of those qualities of mind which are indicated in the first conception of such an idea, and of those other faculties which could alone crown it with demonstration, and add it to the number of established truths. For the attainment, by a single individual, of results so grand and so complete as those which were reached by Newton, each was necessary to the other. But characteristics, which were in him united, have not the less had their separate value when divided in other men; and it cannot be too often repeated, that habits of wakeful observation on the commonest phænomena of nature are often alone enough to yield a rich harvest to the man of science, and to crown his labours with an immortal name. This has been a result of continual recurrence in the progress of knowledge. It is the expression and evidence of a truth of equal importance in the moral and the physical world, that the common things which surround us in our daily life, and many of which we do not really see, only because we see them too often and too familiarly, are governed by principles of infinite interest and value, and whose range of application is wide as the universe of God.

And this brings me to say a word on the value of instruction in Physical Science, not merely with a view to its own advancement, but as in itself a means of mental training and an instrument for the highest purposes of education. It is in this latter point of view that its claims seem to be least admitted or understood. We may bear an exception made in favour of the exact sciences, which involve the application of Mathematical knowledge, since this has been long recognized as requiring the highest intellectual exertion; but with regard to other sciences, how often do we hear them condemned as affording "mere information," and as tending in no sensible degree to strengthen and invigorate the mental powers! But, again I say, this would entirely depend on how Science is to be taught—whether by a mere cramming of facts from manuals, or by explaining how and by whom former

problems have been solved,—what and how vast are other problems yet waiting for, and capable of solution. And even where the researches of Physical Science can do little more than guide conjecture, or illustrate merely what it cannot prove, how grand are the questions which it excites us to ask, and on which it enables us to gather some amount of evidence! In Geology, is it true, or is it not true, that "we can see no trace of a beginning —no symptom of an end?" To what extent, and in what sense are we yet entitled to say, that there has been an advance in organization as there has been advance in time? In Physiology, what is the meaning of that great law, of adherence to type and pattern, standing behind as it were, and in reserve of that other law by which organic structures are specially adapted to special modes of Life? What is the relation between these two laws; and can any light be cast upon it, derived from the history of extinct forms, or from the conditions to which we find that existing forms are subject? In Vegetable Physiology do the same, or similar laws prevail,—or can we trace others, such as those on the relations between structure, form and colour, of which clear indications have already been established, in communications lately made to this Association by Dr. M'Cosh and Dr. Dickie of Belfast? In Chemistry, how is it that some of the most powerful actions escape our finest analyses? In Medicine, what is the action of specifics? and are there no more discoveries to be made such as rewarded the observation of Jenner, in the almost total extinction of a fearful and frequent scourge? It is in reference to such great questions, and ten thousand others equally interesting and important, that the pursuits of science call forth the highest activities of the mind, and exercise every power of thought and reasoning with which it has been endowed.

Indeed it may fairly be questioned whether those sciences which are called exact, are necessarily the best preparation for the actual business of the world. It is the rare exception, and not the rule, when exact and perfect demonstration becomes applicable to the affairs of life. In general, men have to balance between a thousand probabilities, and to take into account a thousand conflicting tendencies. Surely there can be no training better than that which teaches us by what careful inductive reasoning—by what separation between permanent and accidental causes,—by what constant reference from the present to the past, and from the past back again to the present, our existing knowledge has been attained in the paths of physical research. It is true, indeed, that where men's passions and prejudices are much concerned, no amount of teaching will ever induce them to follow or attend to the best methods of arriving at the truth. But even where there are no such disturbing causes, where moderate and candid men are expressing their sincere convictions, how constantly do we hear them ascribing effects to causes, which the slightest habit of correct reasoning would have been sufficient to dismiss! In questions of great social or political, as well as of philosophical importance, the want of such habit is often most painfully apparent, and serves in no small degree to retard the progress of mankind. The necessity of considering all questions with reference to fundamental principles or laws, and these again with reference to the disturbing causes which delay or suspend their operation, the mode of weighing evidence, and the degree of value to be attached to that which is of a merely negative kind—these are things of which we are perpetually reminded in the pursuits of science; and these surely are no useless lessons, whether in religious, social, or political affairs.

And then there is another consideration of no small importance. As Science has now come to a stage in her progress, when she heads the Arts, and flings back upon them her reflected light, so also has she now reached a

degree of development, which casts some rays forward on questions of higher import than those which she can fully answer. It is in vain that we try to draw definite lines between the Physical and the Metaphysical,—between the Secular and the Religious. There is a felt relation between the laws which obtain in each—such indeed as we might expect to find in provinces of a universal empire. The consequence is, that in every speculation on those higher questions on which men will and must speculate—in every system of Philosophy, whether ancient or modern, they draw not merely their illustrations, but not a few of their conclusions from science, or from that which passes by the name. If, therefore, her discoveries, and above all, her methods and her history be but partially and superficially understood, the popular mind will be a perpetual prey to the most specious forms of error. But that history teaches caution. It is full of warning as well as of example. In being a history of the progress of knowledge, it is a history also of the obstructions which Knowledge has encountered, and an index of those to which she is still exposed. The influence of opinions and theories preconceived,—of rash conclusions, and of false analogies, has been, and still is, a perpetual source of danger. So much is this the case, that we soon learn to receive with extreme caution the inferences drawn by men of science from the facts they may bring to light, wherever these inferences touch upon other departments of knowledge. The relation in which a new fact or law stands to others is seldom at once rightly understood. It is only through fightings and controversies of every kind that it gradually finds its place; and becomes, not unfrequently, an instrument in defence of truths which at first it was supposed to sap and undermine. I do not mean to say that the full meaning of the discoveries of science is always brought to light. Far from it. It would be more true to say that their ultimate meaning is never reached; and that for every question which Science answers, she propounds another which it is beyond her powers to solve. But in this we may see the strongest of all arguments against our entertaining any fear of science, as regards the interests of religion. It is sometimes proudly asked, who shall set bounds to Science, or to the widening circle of her horizon? But why should we try to do so, when it is enough to observe that that horizon, however it may be enlarged, is an horizon still—a circle beyond which, however wide it be, there shine, like fixed stars without a parallax, eternal problems in which the march of science never shows any change of place. If there be one fact of which Science reminds us more perpetually than another, it is that we have faculties impelling us to ask questions which we have no powers enabling us to answer. What better lesson of humility than this—what better indication of the reasonableness of looking to a state in which this discrepancy shall be done away; and when we shall "know, even as we are known!"

But, Gentlemen, I have already detained you too long, and occupied your time far less profitably than it would have been occupied by many who are present on this occasion. The hospitality of this great city will afford you, I trust, a pleasant, and your own exertions will secure a profitable, Meeting. You may well engage in its business and discussions, with a sense of the high interest and value of your pursuits—not less interesting in themselves, —not less conducive to the progress and happiness of mankind,—not less tasking the noblest faculties of the mind, than those which engross the attention of jurists, of soldiers or of statesmen, when their motives are the purest, and their objects are the best.

REPORTS

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Report on the Relation between Explosions in Coal-mines and Revolving Storms. By THOMAS DOBSON, *B.A., of St. John's College, Cambridge.*

IN coal-mines liable to explosions, there is a continuous discharge of carburetted hydrogen gas, from the innumerable minute fissures of the fractured coal, into the galleries of the mine. The rate and quantity of this issue of gas depend, *cæteris paribus*, upon the density of the atmosphere; being greater when this density is less, and *vice versâ*. The preponderance of air over gas in the atmosphere of the mine never falls below a certain fixed ratio without producing a risk of explosion; hence a due adjustment must be maintained at all times between the rates of ventilation and of gaseous discharge, in order to prevent the mine from becoming charged with gas up to the explosive point.

It is here proposed to consider the effect of extraordinary fluctuations of the density and temperature of the atmosphere in deranging this delicate adjustment of opposing powers.

There are two ways in which meteorological agency may render the atmosphere of a mine explosive.

1. During a period of comparatively calm weather, when the mercury in the barometer ranges above 30 inches for several days, the usual escape of gas into the mine is checked by the greater density of the air, and the tension of the pent-up gases increases. If such a period be succeeded by a rapid diminution of atmospheric pressure, indicated by a considerable fall of the mercurial column, the consequent outpouring of suddenly liberated gas may be so great as to overpower the ordinary ventilation of the mine, and thus an explosive atmosphere may be produced by *an excessive issue of gas, owing to a sudden decrease of atmospheric pressure.*

2. Supposing the action of the ventilating mechanism to remain unchanged and the flow of gas into the mine to be steady and constant in quantity, it is evident that the *effective ventilation* will vary inversely as the temperature of the external air. In fact, the efficiency of the ventilation depends chiefly upon the *difference* of temperature of the air in the mine and the air aboveground. Hence a considerable rise in the temperature of the external air may so impede the ventilation as to render it inadequate to effect the necessary dilution and removal of even the ordinary quantity of gas discharged;

and the atmosphere of a mine may thus become explosive from *a want of sufficient air*, *owing to a sudden increase of atmospheric temperature.*

There are two distinct and essential conditions necessary to cause an explosion in a coal-mine:—

1st. The atmosphere of the mine must be rendered inflammable.

2ndly. The inflammable air must be ignited.

The condition of inflammability may occasionally arise from a workman unexpectedly breaking into a reservoir of accumulated gas; from the fall of the roof of a Goaf, or old waste; or from the accidental derangement of the ventilating machinery. Such fortuitous cases do not belong to the present inquiry.

As the *instant of ignition* is independent of the weather, and is generally determined by an individual act of carelessness, it is obvious that any reasoning based on the action of the barometer or thermometer *just at the time of explosion* will be apt to lead to conflicting and even erroneous results. This will appear more plainly from a brief consideration of the attempts that have been made hitherto to determine the relation between explosions in coal-mines and atmospherical fluctuations.

In the minutes of evidence on "Accidents in Coal-mines," taken before a Select Committee of the House of Lords in 1849, is a table, constructed by J. Hutchinson, Esq., M.D., of thirty of the "chief explosions" since 1800 in Northumberland and Durham, with one daily reading of the barometer and thermometer at Newcastle-upon-Tyne, for each of three days, of which the day of explosion is the last. The mean action of the barometer on the thirty days of explosion is found to be a depression of ·02 (two-hundredths) of an inch; and that of the thermometer an elevation of one degree. Hence it is concluded that the relation between such explosions and the barometer is "feeble" compared with their relation to the thermometer (Parl. Report, &c., 1849, p. 154).

T. J. Taylor, Esq., an eminent colliery-viewer in the North of England, has selected twenty-five of the "great pit-explosions" in the same district, and likewise tabulated a single barometrical reading at Newcastle-upon-Tyne, for each of three days, of which the second is the day of explosion (*Idem*, p. 557).

These tables have been generally accepted as conclusive against the connexion between a falling barometer and explosions in coal-mines. In a particular instance, where a great fall of the barometric column immediately preceded a fatal explosion, a Government Inspector of Mines cites these tables as the basis of his opinion that the fall of the mercury had *no effect* in producing the explosion referred to (Parl. Report, &c. 1853, Qu. 543, 568).

The following considerations will show that the nugatory result of these tables is really no evidence of the absence of meteorological influences.

1st. By selecting the *explosion* for the *critical phænomenon* of the inquiry, the numerous cases are excluded where explosions have been foreseen and prevented, when the atmosphere of the mine has been observed to have become highly inflammable before it was too late to retreat. Two instructive instances of this kind are mentioned in a letter of the 24th Sept. 1839, from T. D. Brown, Esq., the owner of Jarrow Colliery, published in the Appendix to the able Report of the South Shields Committee. Mr. Brown writes, "On the 1st Sept. I find the barometer stood at 28·81 inches. The master-wasteman's account of the state of the air in Jarrow pit on that day is, that it was so bad that the gas came to the shaft. On the day of the *great storm* (7th January, 1839) my barometer was down to 27·48 inches, and the wasteman's account is, that he seldom, if ever, knew a pit to be in such a state. The gas came

to the shaft in the Bensham; and having made its appearance in the Bensham engine chimney, it was found necessary to extinguish the fire. The wasteman says that the glass does not fall two degrees without a change being perceptible below."

Notwithstanding the absence of an explosion in each of these cases, it is manifest that the readings 28·81 and 27·48 ought to have appeared in the tables.

2ndly. By estimating the *importance* of the explosion by the *number of persons killed*, the great explosions are omitted which have occurred at times when few persons were in the mine.

3rdly. By taking *all* the *great explosions*, some cases are included which have arisen from known accidental causes, unconnected with atmospherical changes.

These tables are, therefore, defective with respect to a large and important class of cases, and redundant with respect to others which have no relation to meteorological agency. But even if they had been perfect, the results would still have been illusory, so long as the attention was confined to the action of the barometer and thermometer *at the time of explosion*; for the transit of a great atmospheric storm generally occupies several days, during which a mine may continue in a "foul" and dangerous state, ready to explode at any stage of the storm's progress. The mercurial column, therefore, at the time of explosion, may have any length comprised within the extreme limits of the range of the barometer. The condition of ignition, and therefore the explosion, may even be deferred until the storm has entirely passed over, and the mercury has resumed the height and stability peculiar to settled weather.

Thus, on the 3rd and 4th of November 1850, "a most violent storm of wind" caused great loss of life and property in Great Britain; blowing down walls, chimneys, trees, &c. on land, and destroying many vessels along the coasts. At the Royal Observatory, Greenwich, the passage of the storm is recognized by a sudden and considerable depression of the mercury on the 3rd and 4th of November, but the readings range above 30 inches on the 9th, 10th, and 11th (see Plate V.).

On the 11th of November, twenty-six persons perished by an explosion in the Houghton pit, Newbottle, county of Durham.

The remark that "the workmen had been apprehensive of an explosion for *more than a week*," connects this accident with the storm of the preceding week.

That such cases of delayed danger are not uncommon, appears from the following statement of Mr. Mather to the Parliamentary Committee in 1854 (Second Report, &c., Qu. 1564). "The Killingworth explosion was previously indicated for eight days by three separate explosions; the Washington explosion gave notice for five weeks of the coming catastrophe; and Wallsend, that killed 102 people, showed its state for three days in red-hot Davy-lamps. All of them gave large and decided indications of gas being present for days before they happened; and these are some of the chief accidents that have occurred. In one instance there was, for a period of six weeks, carburetted hydrogen to be found in a most positive manner."

The opinion that explosions in coal-mines are, in some manner, dependent upon certain changes in the ordinary conditions of the atmosphere, seems to have been long entertained by the colliers of the various mining districts of Great Britain and France; and is repeatedly expressed in the minutes of evidence taken by the Select Committee of the House of Lords on "Accidents in Coal-mines," in 1849; and by the several Committees of the House of Commons, on the same subject, in 1835, 1852, 1853, and 1854.

It appears to have been satisfactorily established by observation, that the

inflammable carburetted hydrogen gas oozes out from the coal into the mine in greatest abundance (and, therefore, that the danger of explosion is greatest) when the *barometer has fallen considerably*, and a *warm wind* blows from the *south-east, south*, or *south-west* points of the compass; and that, on the contrary, the mine is most free from gas, and explosions are least frequent, when the *barometer is high* and the wind *cold* and *northerly*.

A brief exposition here, of the general nature of the great storms which pass over the British Islands and the continent of Europe, will help to a right understanding of the special cases to be afterwards considered; and will also show that the several meteorological conditions which have been so often observed to precede, or accompany, a highly inflammable state of the atmosphere of a coal-mine, are only so many direct consequences of the "Law of Storms" in the Northern Hemisphere.

From the valuable work of Colonel Reid "On the Law of Storms and of the Variable Winds" (Weale, London, 1849), it appears that the great storms which sweep over Britain and the Continent of Europe during the autumnal and winter months, rise first among the West Indian Islands; and after coasting along the sea-board of the United States, cross the Atlantic Ocean in a north-easterly direction.

These storms are simply immense aërial eddies, or whirlwinds, which expand gradually as they proceed; their mean diameter frequently extending a thousand miles by the time that they impinge upon Ireland and the western coast of Scotland, England, and France. In the course of a few days, such a storm passes over France and the British Isles, to Belgium, Holland, Germany, Denmark, Sweden, and the Baltic Sea (Plate I.).

The atmospheric pressure diminishes continuously, but at an accelerated rate, from the circumference towards the centre of a revolving storm. Hence, if a chord be drawn parallel to the track of the centre, to represent the part of the storm that passes over any assigned place, the mercury at that place will fall until the middle of the chord arrives there; and will rise, at first rapidly, but afterwards more and more slowly, as the second half of the storm is passing over. It follows that the greatest local depression of the mercury will occur simultaneously at all places situated on the diameter perpendicular to the track of the cyclone.

In the cyclones of the Northern Hemisphere, the wind *turns* in a direction contrary to the motion of the hands of a watch, so that when a revolving storm approaches Britain, the mercury begins to fall, and a *warm wind* to blow from the southward. *These are precisely the circumstances under which experience has proved that coal-mines are most liable to explosion.*

As the diameter of simultaneous local maximum depression advances, the mercury falls faster at any place in front of the storm, and the violence of the wind increases there.

The general track of cyclones passing over Britain tends towards the E.N.E. Therefore, if the storm begins at S.E., S., and S.W. respectively, at three different places, the *wind will shift* during the transit of the cyclone, from S.E. through E. to N. at the first place; from S. through W. to N.W. at the second place; and from S.W. to W. at the third place.

This *shifting* of the wind, which indicates a passing cyclone, is reckoned by miners among the symptoms of danger. J. Roberts, Esq., Colliery Owner in Dean Forest, stated before the Committee of 1849 (Qu. 6272) that the gas in those mines generally occurs as the wind shifts.

The diagram (Plate I.) is adapted from the Chart at page 323 of Colonel Reid's work, and represents the storm of November 1838. I have added the mean direction (E.N.E.) of progression, and drawn chords through

Wick in Scotland, Dublin and Newcastle-upon-Tyne, Dover, and Oporto, to illustrate the successive phases of the cyclone during its passage over these respective places. At Wick, the wind shifts from S.E. through E. to N., and blows hardest at E.N.E. At Dover, the wind shifts from S. through W. to N.W., and blows hardest at W.S.W. At Oporto, the wind shifts from S.W. to W., and blows hardest at W.S.W.

The centre passes over Dublin and Newcastle-upon-Tyne, where the wind shifts abruptly from S.S.E. to N.N.W., a short lull probably preceding the change of wind. Here the mercury falls lowest.

Since all the different coal-fields of Britain are sometimes subjected to the action of one cyclone at the same time, the occurrence of *nearly simultaneous explosions* in mines far apart may be anticipated; and since storms travel towards the E.N.E., explosions in the coal-mines of France, Belgium, &c. will sometimes happen a day or two after a great storm has passed over the British Islands. If the number of such cases is found to be considerable, it will be a strong proof of the connexion between revolving storms and explosions in coal-mines. This proof will be confirmed by our finding that after an entire absence of explosions for many weeks, several occur almost simultaneously, just after the arrival at Britain of some extraordinary atmospheric paroxysm, which has already devastated the islands and shores of the Gulf of Mexico, and the sea-board of the United States, and left several wrecked and disabled ships in the rear during its eastward course across the Atlantic.

Unfortunately our mining records are defective with regard to two large classes of phænomena, which are eligible as evidence in this inquiry. They seldom notice explosions which have *not* been *fatal* to human life, and they contain no account of cases like those at Jarrow in 1839, where mines have been filled with gas during stormy weather, and explosions have been prevented.

In order to ascertain the relation between explosions and the seasons of the year, Mr. Taylor has arranged, in monthly periods, a table of 115 of the chief explosions during forty years in the north of England (Parl. Report, &c., 1849, p. 572).

Up to the end of 1854 there are recorded 514 explosions in British coal-mines. With these I have constructed, in monthly periods, the curve A (Plate II.), which agrees remarkably well with the corresponding curve B, formed from the 115 explosions selected by Mr. Taylor. In the curve C, I have grouped all the explosions (491) of which the day of occurrence is known, in 73 periods of 5 days each. The *minimum* for the year in A is 23, and falls in February; in B is 3, and falls in January and February; and in C is 1, and falls in January 20–25.

The *maximum* for the year in A is 55, and falls in June; in B is 15, and falls in June and December; in C is 12, and falls June 9–14, and July 9–14.

The persistent character of these curves, with respect to the places of their maxima and minima, proves indisputably the *general* dependence of explosions in coal-mines upon the seasons of the year.

The lowest temperature of the year occurs between the middle of January and the middle of February. The ventilation of mines is consequently most active during these months; and accordingly the curves show that this is the season least liable to explosions.

As the temperature increases, explosions are more frequent, until the highest temperature and the greatest number of explosions take place together in June and July. In September the curve descends, that is, the number of explosions is less as the temperature decreases. The rise of the curve at the end of September, and the great number of explosions in October, November, and

December, is due chiefly to the frequent and sudden diminutions of atmospheric pressure which accompany the storms that prevail during these months.

The advent of a cyclone to Britain produces both the meteorological conditions which tend to make the atmosphere of a mine explosive. The barometer falls and the thermometer rises. The examination of particular instances of explosions will show that both causes frequently concur in producing them. But from March to August a *rising thermometer* is the exponent of danger from the *predominating* meteorological agent, and a *falling barometer* is the corresponding exponent from August to January; while the curves indicate that the increased activity of the effective ventilation renders January and February a period of comparative safety, so far as atmospherical influences are concerned.

The list of dates of colliery explosions begins in 1743, and often presents a *hiatus* of four or five years in its earlier portion, when collieries were few, and the more fatal cases only were recorded. Of the 514 cases in my list, considerably more than one-half have occurred during the last five years. The rate of increasing carefulness in observing and publishing such catastrophes, may be estimated by the numbers of known explosions for each year since 1849. These were—22 in 1850; 53 in 1851; 67 in 1852; 75 in 1853, and 77 in 1854. Old meteorological registers are also much less complete than those of recent years.

The most satisfactory method, therefore, of forming a correct opinion of the nature and extent of meteorological influences in producing an explosive atmosphere in mines, would be to take, as a standard of comparison, the barometrical and thermometrical curves for the last five or six years, constructed from *several* daily readings made at some observatory situated near the centre of the colliery districts.

By way of illustration, I shall examine the meteorological conditions which were simultaneous with, or which immediately preceded, the explosions in British coal-mines during the end of 1851 and the whole of 1852. I have taken the Greenwich Observations for 1851; and for 1852 the Manchester Observations, which were laid before the Parliamentary Committee of 1854 by Mr. Dickenson, Government Inspector of Mines. The Manchester observations have been carefully compared with the contemporaneous observations at the Royal Observatory at Greenwich, and those made at Highfield House, near Nottingham, by Mr. Lowe.

In all the curves I have drawn the vertical fluctuations of the barometer of the actual size, and those of the thermometer to a scale of 10° to an inch. The barometrical line of 30 inches coincides with the thermal line of 70°; except during the first three months of 1852, when it coincides with the thermal line of 60°, in order to save space.

The *upper* thermal line indicates the *diurnal*, and the *lower* the *nocturnal* temperature.

In the continuous curves for 1851 and 1852, each day is represented by a lateral space of $\frac{1}{20}$th of an inch, but in the barometrical curves of isolated cyclones, by $\frac{1}{10}$th of an inch.

In the vertical strip denoting a day of explosion, the space between the barometric curve and the line of 30 inches is shaded, as also the space included between the two thermal lines; the shade being *deeper* where more explosions than one occur on the same day. This arrangement enables the eye to perceive readily the *height* of the barometer, and the *height* and *range* of the thermometer on the day of explosion; and to compare them with those of the preceding days.

The mere inspection of these curves will show that explosions *very seldom* take place without the *direct* and *manifest concurrence* of *one* or *both* of the meteorological conditions which tend to produce an explosive atmosphere in mines.

Explosions in October 1851 (see Plate I.).

Oct. 13, Ince Hall Colliery, Wigan.
" 13, Grange Colliery, Wakefield.
" 20, Dewsbury, Yorkshire.
Oct. 27, Glasshouse Colliery, Leeds.
" 30, Clifton Colliery, Halifax.
" 31, Killingworth Colliery, Newcastle.

All fatal explosions; at Killingworth eight killed and six burnt.

The approach of a cyclone raises the temperature 10° on the 12th and 13th, and a depression of an inch of the barometer takes place by the 15th. *Two* explosions on the *same day* coincide with this marked rise of both the nocturnal and diurnal temperature.

From the 20th to the 27th both thermal lines are high, but the explosions of the 30th and 31st seem to have been influenced chiefly by the extreme barometric depression on the 27th, 28th, and 29th.

During the following *five weeks* there are *no explosions*, for *both* the favourable atmospheric conditions are *wanting*. The barometer is always above 29·50, and there are *no great and rapid falls of the mercury*. The nocturnal and diurnal temperatures are both *excessively low* during the whole time. The absence of explosions at such a time is quite as significant as their presence when the favourable conditions exist.

Explosions in December 1851.

Dec. 6, Woodthorpe Colliery, Sheffield (three killed).
Dec. 20, Rawmarsh Colliery, Rotherham (fifty-two killed).
" 22, Ince Hall Colliery, Wigan, Lancashire (thirteen killed).

On each of these days the diagram shows a very marked *rise* of *both* the thermal lines, induced by the south wind in front of two cyclones; of which the former is scarcely recognized at Greenwich on the 8th and 9th, but in the latter, the diminished pressure manifestly conspires with the increased temperature to produce the serious catastrophes of the 20th and 22nd.

Explosions in January 1852 (see Plate III.).

Jan. 9, Pemberton Colliery, Wigan.
Jan. 26, Ringley Colliery, Manchester.
" 26, Stoneclough Colliery, Kearsley.
" 27, Rothwell Haigh, Leeds.

"The gales of January caused 126 casualties (at sea); they prevailed during the whole month, and the early part of February." (Parl. Return of Wrecks for 1852.)

On the 8th and 9th the most violent snow-storm for many years raged over the British Isles. This was a regular cyclone, passing to the Texel on the 11th, &c. Wind S.W. on 7th and 8th, N.E. on 8th and 9th.

On the 24th are recorded a tempest and many wrecks in the English Channel and on the east coast, as well as a most destructive tornado at Nenagh in Ireland. On the 26th and 27th, storms and wrecks again occur, and on the 5th of February the consequent inundations at Holmfirth in Yorkshire. The great barometrical depressions show the passage of several successive cyclones in January, some of which were probably derived from the great hurricane that destroyed fourteen ships at Vera Cruz, in the Gulf of Mexico, on the 13th.

Explosions in March 1852.

Mar. 13, Blackleyhurst Colliery.
" 15, Coate's Park, Alfreton.
" 18, Ince Hall Colliery, Wigan.
Mar. 22, Albion Colliery.
" 23, Bayleyfield Colliery.

During the whole of February, with one exception, the barometer ranges high. It is also unusually high in the first week of March. The fall of about half an inch before the 11th, together with the contemporaneous rise of the nocturnal temperature, may have liberated a sufficient quantity of the accumulated gas to produce the explosions of the 13th, 15th, and 18th. The predominant agent, however, is unmistakeable on the 22nd and 23rd. A letter in the 'Times' of the 24th, signed P. P. B. M. (Byam Martin ?), Dorchester, describes the approach to Britain on those days of a cyclone, which veered from S.W. to N.E. Its arrival caused an extreme increase of temperature over the whole island. The Manchester curves rise to 45° at night, and 62° in the day, on the 22nd; and at Perth the thermometer was 61° on the 23rd. At Nottingham, the maxima readings are 61°·5 on the 21st, 71°·5 on the 22nd, 70° on the 23rd, and 49°·5 on the 24th. The temperature was therefore 10°, or an inch of vertical space, higher than shown by the Manchester curve on the 22nd. The wind on the 22nd and 23rd was S.W., and then veered to N.E. This is a striking instance of the effect of a cyclone in impeding the ventilation of mines by augmenting the external temperature.

Explosions in April 1852.

April 3, Smithfold Colliery.
" 11, Yewtree Colliery.
" 13, Hulton Colliery.
April 16, Ince Hall Colliery, Wigan.
" 23, Norleyhall Colliery, Wigan.
" 28, Dukinfield Colliery, Cheshire.

Barometric agency is manifested in the explosions of the 3rd and 28th of April. In the other cases, the thermal lines show the predisposing cause. A hard gale blew from S.E. and E. on the 22nd and 23rd, and from W.S.W. on the 28th, shifting to E.N.E. on the 29th.

Explosions in May 1852.

May 6, Hebburn (twenty-two killed).
" 10, Aberdare (sixty-five killed).
" 11, Hyde and Gerard's Bridge Colliery.
May 20, Preston (thirty-four killed).
" 28, Preston (four burnt).
" 28, Birket Park Colliery.
" 29, Broad Oak Colliery.

The West Indian steamship 'Medway' arrived at Southampton on the 8th of May, having been overtaken by strong easterly gales (the northern margin of a West Indian cyclone) on the 3rd and 4th. The barometric curve shows this cyclone to have passed over England between the 6th and 22nd of May. The curve shows also the consequent rise of temperature at Manchester. At Nottingham this rise was equally remarkable, the maximum readings there having been 55° on the 5th, 65°·6 on the 6th, and 74° on the 7th of May. On the 9th, 10th, and 11th there was very stormy weather at sea from the S.W., shifting to N.W. on the 14th.

Another cyclone reached Europe at the end of May, which seems to have been more felt on the continent than in England. There were violent storms of hail, lightning, &c. on the 29th at Amsterdam, Caen, Leipsic, &c., and great loss from the ensuing inundations at Cette, &c. in the South of France.

Explosions in June 1852.

June 14, Bilston Colliery (five killed, seventeen burnt).
June 28, Sankey Brook Colliery.

A cyclonic depression of the barometric curve extends through nearly the whole of June, the centre passing between the 13th and 16th, when strong winds blew, shifting from S. to N.E. on the 16th. The observations at Nottingham on the 14th are—10 A.M., thunder-storm until 7·30 P.M., wind W., barometer rising; thermometer 63°·5 at 2·30 P.M., and 66° at 3·40 P.M. In the Manchester curves, both the thermal lines rise considerably from the middle to the end of the month, which was distinguished by a very general perturbation of the atmosphere; thus, on the 27th of June there was a heavy storm of thunder, lightning and rain at Glasgow, and a waterspout near Irvine; on the 28th a great storm at Belfast, and on the 29th a S.W. gale at Queenstown.

Explosions in July 1852 (Plate IV.).

July 4, Jackfield Colliery, Burslem.
„ 6, Beeston Manor Colliery, Leeds.
„ 8, Monkwearmouth Colliery.
„ 15, Alfreton Colliery.
„ 16, Foley Colliery, Longton.
July 17, High Green Colliery, Sheffield.
„ 24, Tillerey Colliery, Monmouthshire.
„ 27, Haydock Colliery, Warrington.
„ 30, Silkstone Colliery, Barnsley.

"In July, the maximum temperature was very high and steady, rising at times above 90°, and once reaching 92°·5." (Mr. Lowe.)

It is unnecessary to particularize here the dates of the thunder-storms, waterspouts, &c. which occurred during this month of excessive warmth. The thermal curves indicate distinctly the coincidence of days of explosion and of increased temperature.

Explosions in August 1852.

Aug. 6, Manor Park Colliery, Belper.
„ 13, Bradshaw House Colliery, Wigan.
„ 16, Ubberley Colliery, Hanley.
Aug. 23, Sutherland Colliery, Dudley.
„ 30, Bredbury Mine, Cheshire.

A great cyclone, accompanied by thunder-storms and very violent gales all over the kingdom, is characterized in the barometric curve by a depression extending from the 1st to the 20th of August. The southerly gale of the 11th and 12th is described as the most violent for many years. The gale is from the N.N.W. on the 15th. Its subsequent arrival on the continent is marked by a destructive hailstorm and waterspout in Wirtemberg on the 19th, a great storm at Leipsic on the 28th and 31st, &c. The thermal lines continue high during the whole month.

Explosions in September 1852.

Sept. 5, Little Lever Colliery, Bolton.
„ 16, Glodwich Colliery, Oldham.
„ 17, Brymbo Colliery, Denbigh.
„ 18, Little Hulton Colliery, Lancashire.
Sept. 22, Winnington Wood Colliery, Newport.
„ 24, Hunsworth Colliery, Bradford.
„ 25, Roway Colliery, Tipton.

Several very severe West Indian hurricanes crossed the Atlantic Ocean during the autumn and winter of 1852. A very destructive cyclone blew at Mobile from the 23rd to the 26th of August, and afterwards travelled along the east coast of the United States from Virginia to Maine. A month afterwards another great cyclone devastated Antigua, Martinique, &c. on the 22nd and 23rd of September, and a third reached its climax at Jamaica on the 6th of October.

The barometric curve in England presents a succession of extreme fluctuations derived from the violent atmospheric paroxysms in the Western Atlantic.

At Highfield House, Nottingham, on the 5th of September, there was a brief but heavy storm in the evening, and on the 6th a great thunder-storm. Nearly $2\frac{1}{2}$ inches of rain fell in twenty-four hours. From the 14th to the

22nd the depression characteristic of a great cyclone appears in the barometric curve.

At Leipsic, the first impression of the approaching cyclone appears on the 17th, on which day more rain fell there than on any day during the preceding sixty years. On the 19th the barometer fell to 327 Paris lines, and on the 20th there was a tornado. *Notwithstanding* the excessive decrease of temperature which the thermal lines indicate during the passage over Britain of the *central portion* of this cyclone, there are three explosions on three consecutive days, in the very midst of the cyclonic barometric depression.

On the 21st the barometer rises about an inch, but *both* the thermal lines rise also, and explosions follow on the 22nd and 24th. These accidents were therefore induced both by diminished pressure and increased temperature; but so far as meteorological agency is concerned, the explosions of the 16th, 17th and 18th were due to diminished atmospheric pressure alone.

Explosions in October 1852.

Oct. 4, Horsehay Colliery, Dawley.
,, 4, Willfield Colliery, Longton.
,, 6, Cwmbargoed, Dowlais, S. Wales.
,, 8, Cwmbach, Aberdare, S. Wales.
Oct. 12, Worsley Colliery, Lancashire.
,, 22, Tyrnicholas Colliery, Monmouthshire.
,, 27, Monkwearmouth Colliery, Durham.
,, 29, Dudley-port Colliery.

From the 28th of September to the 10th of October, another cyclonic depression occurs, the mercury sinking to 28·75 on the 4th of October. *Two explosions happen on this day*, and three others follow on the 6th, 8th, and 12th respectively. The weather was excessively stormy until the 10th, both here and on the continent. At Portsmouth, on the 4th and 5th, "a truly awful gale" blew from the S.S.W., and there was a destructive inundation and a hurricane of wind at Lewes. On the 6th and 7th, after the centre of the cyclone had passed, an unusually severe storm of wind blew from N.E. in Scotland. On the 29th of September, 1 A.M., the ship 'Mobile,' 1000 tons, from Liverpool, in a hurricane from N., went to pieces in the Irish Channel; sixty lives were lost. Many other wrecks occurred.

A great barometric depression begins on the 20th of October, and extends to the 8th of November. On the 22nd of October both thermal lines rise considerably, and the barometer has fallen half an inch. The temperature is low on the 27th and 29th, but the great barometric depression is quite sufficient to account for the explosions on these days.

The barometer was 28·75 on the 26th. Many vessels, and upwards of 100 lives, were lost on the 26th and 27th, during the storm at Shields, Sunderland, &c. At Cologne the barometer is lowest (327 lines) on the 27th. The cyclone began here with a gale from S.E., and shifted to N.E.

In the Parliamentary Return of Wrecks for 1852 it is stated, that "on the 26th of October an easterly gale began that in six days strewed the coasts with 102 wrecks."

Explosions in November 1852.

Nov. 6, Winstanley Colliery, Wigan.
,, 11, Bryndu Colliery, Pyle.
,, 17, Stoneclough Colliery, Kearsley, Lancashire.
Nov. 20, N. Brierly Colliery, Bradford.
,, 22, Plat Lane Colliery, Wigan.
,, 26, Coate's Park Colliery, Alfreton.
,, 28, Hadden Mill Colliery, Dudley, Staffordshire.

On the 6th the thermal lines are high; but the temperature is low during the rest of the month. The remaining explosions of this month coincide in a most striking manner with the great barometric depressions. Hurricanes of wind, wrecks and great inundations all over the kingdom, marked the

presence of the cyclone which the curve indicates to have arrived on the 12th of November.

Explosions in December 1852.

Dec. 2 and 14, Abersychan.
,, 16, Blackleyhurst Colliery, St. Helen's.
,, 22, Elsecar Colliery, Barnsley.
Dec. 27, Comrie, Culross, Perthshire.
,, 27, Titwood Colliery, Pollockshaws, Glasgow.
,, 29, Pendlebury Colliery, Lancashire.
,, 31, Seghill Colliery, Northumberland.

Mr. Lowe states that "the gales of December were all accompanied by *hot weather* for the time of year," which is also shown by the Manchester thermal lines. The explosion on the 2nd of December was probably a consequence of the cyclone just past. From the 17th to the 18th of December, the barometer at Manchester rose an inch and a quarter, *i. e.* from 28·85 to 30·10. In Peebleshire, the simultaneous rise was from 27·90 to 29·60. This sudden rise of the barometer marks the exit of a cyclone all over the world.

Another cyclone, which had more of the violence of a tropical hurricane than is usual in Britain, began to reach England on the 18th of December, and did not entirely pass over until the 1st of January 1853. The hurricane began at S.W., shifting to W.S.W., and blew hardest on the 26th and 27th. The 'Times' of the 29th has several columns of details of losses of ships and lives. The following is from the Parliamentary Return of Wrecks for 1852: "On the 24th of December a heavy storm from the S.W. burst over the country, and continued to the end of the year with such violence, that by the 29th there was scarcely a vessel in the neighbourhood of the British Islands left at sea. Some had found safety by running into port; while of others, the returns show a list of 183 casualties; of these 102 were totally wrecked, making an average of thirty wrecks a day during this awful and destructive gale."

Two explosions on the very day of the greatest barometrical depression are indisputable witnesses of the effect of greatly diminished atmospheric pressure.

Explosions in January 1853.

Jan. 2, Titwood, Pollockshaws, Glasgow.
,, 3, Leasingthorne Colliery, North of England.
,, 5, 6, Seghill Colliery, North of England.
Jan. 9, Trubshaw Colliery, Newcastle-under-Lyne.
,, 10, Smallbridge Colliery, Rochdale.

The weather was still unsettled in the early part of January, and these explosions were doubtless partly induced by the great atmospheric paroxysm that had just occurred.

From the 10th of January to the 12th of February there were no explosions, which corresponds with the indications of the general curve respecting the season of lowest annual temperature.

Before quitting this examination, let the winter curves for 1851 and 1852 be placed in juxtaposition, and the different conditions of atmospheric pressure and temperature carefully noted, and it will be at once apparent why there were so many as seven fatal explosions in November 1852, and *none* in November 1851; and so many as eight fatal explosions in December 1852, and only three in December 1851.

In order to corroborate the evidence already adduced in proof of the connexion between revolving storms and explosions in coal-mines, I have selected the following from a considerable number of cases in which explosions have occurred either during or immediately after the passage of a cyclone.

In a few instances I have given the contemporaneous barometric curves at two or three stations far apart, as London, Versailles, and Goersdorf on the Lower Rhine; London and Rouen, &c.

1784.—The diagram (Plate II.) shows the barometric curve at London, from observations published in the 'Gentleman's Magazine' of the time, in December. On the 6th the mercury fell to 28·25 inches. A general storm of unusual violence accompanied this great depression.

Only two explosions are recorded in this year, of which one (at Wallsend, Northumberland) occurs before the rear of the cyclone has passed over, on the 12th of December.

1818, April 9.—By a great explosion at Warnes, near Mons, between thirty and forty persons lost their lives on this day.

The curve (Plate V.) shows that a regular cyclone passed over Britain from the 5th to the 12th. Howard, in his 'Climate of London,' records a gale from the S. on the 8th, and states the 9th, 10th, and 11th to have been windy. No explosions are recorded in Britain during 1818.

1821, October.—From the 30th of September to the 9th of October, 1821, a regular West Indian hurricane, beginning at N.N.E. and ending at S.S.W. (and therefore progressing towards Florida, Newfoundland and Great Britain), blew between Jamaica and Cuba (Howard, vol. iii. p. 63).

The great barometric depression at London (Plate V.), from observations by Howard, between the 16th and 26th, indicates the passage of this cyclone over England. The barometer was equally low at Newcastle-upon-Tyne.

There are *five* explosions recorded in 1821, *two* on the same day, July 9, at Rainton Colliery and Coxlodge Colliery, in the North of England, coincident with a rise of temperature, and the remaining three just as the central area of this cyclone was passing over Britain. These also occur in the North of England; thus—on October 19, at Nesham's Pit, Newbottle (six killed); Oct. 23, Russel's Pit, Wallsend (fifty-two killed); Oct. 23, Felling Colliery (six killed).

1823, November.—A great storm passed over Britain at the end of October. On the 30th and 31st alone, 140 vessels were lost on the N.E. coast. At Penzance, the wind suddenly shifted from E.S.E. to N.E. and N.N.E., and instantly blew a hurricane. This shows the progressive motion of a revolving storm to the eastward. In Plate II. are given the barometric curves for London and Boston during the transit of this cyclone.

On November 3, before the storm had ceased, an explosion at Plain Pit, Rainton, Durham, destroyed fifty-nine men. This, and an explosion at Ouston Colliery on the 21st of February, are all that are recorded during 1823.

1828, Nov. 20.—At Washington Colliery fourteen persons killed by an explosion. Howard's curve (Plate II.) shows that a great barometric depression immediately preceded this catastrophe.

1844, January.—A very heavy storm of thunder, lightning, hail and rain, passed over the counties of Lancashire and Cheshire on the 1st of January. The barometric curve at Makerstoun shows that the storm was general and lasted for several days. The contemporaneous explosions are on December 31, 1843, Hulton Pit; on January 8, 1844, Dynas Pit, Glamorganshire (ten killed); Jan. 11, Whitehaven, Cumberland (sixteen killed); Jan. 18, Killingworth Colliery, Northumberland (five killed).

1844, October.—The great Cuba hurricane, investigated by Redfield, occurred on the 3rd and 4th of October at Cuba and Jamaica, and passing over Florida, the Bahamas, &c. in a N.E. track, reached Newfoundland on the 8th (see Col. Reid's work). At Havannah, seventy-two ships were wrecked or sunk, houses were unroofed, crops destroyed, &c., the estimated loss there

being £1,000,000. At Matanzas, in Cuba, the barometer, which usually stands at 30 inches, fell to 28 inches on the 5th, and rose to 29·8 by 9 A.M. of the 6th. Many vessels were destroyed at Jamaica, &c. The barometric curve at Highfield House, Nottingham, shows that this great cyclone caused a succession of depressions between the 2nd and 24th in Britain. The central area passed on the 14th, 15th and 16th. The barometer is 28·56 on the 15th. The wind is S.W. until the 13th; then W. till the 16th, and afterwards N.W. till the 19th. The arrival of the cyclone on the continent is accompanied by a destructive waterspout at Cette on the 22nd, which destroyed thirty persons and many buildings; and by a great storm at Toulouse on the 24th, followed by inundations at Marseilles, Avignon, &c.

Two explosions occur in the very midst of this storm, viz. on Oct. 15, at Coxlodge Colliery, North of England (one killed); Oct. 19, Rowley Regis, Staffordshire (eleven killed).

1845, August.—In Plate V. I have given the barometric curves for August at Greenwich and Rouen, which shows that the atmospheric disturbance passed from England to France. The remarks at Greenwich are—Aug. 2, thunderstorm, rain, lightning; gusty. Aug. 9, wind and rain; gusty. Aug. 19, rain and wind. The atmospherical disturbance on the 19th was very general. In Holland, on the 19th, at Zevenberghem, a hurricane destroyed eleven buildings, killed three persons, and injured several others. The same tempest caused great damage in North Brabant, &c. At Rouen, on the 19th, a whirlwind destroyed the three principal factories, killing seventy-five persons and wounding 150 others; the wind was violent from the S.W. On the 20th of August there were snow-storms in England and Scotland, in which several boats with their crews perished. The explosions in coal-mines during this month were,—on Aug. 2, at Aberdare (twenty-nine killed); Aug. 9, Ashby-de-la-Zouch, Leicester (three killed and fifteen burnt); Aug. 18th, Dudley, Staffordshire (four killed and sixteen burnt); Aug. 21, Jarrow, Durham (thirty-nine killed).

At Newcastle-upon-Tyne the wind was N.W. on the 21st, and the daily barometrical readings are 29·47, 29·81, 30·05; which agree with the Greenwich and Rouen curves, and indicate the passage of the rear of the cyclone.

1846, September and October (Plate V.).—From the 4th to the 9th of September, a storm passed over Britain. On the 7th a woman was killed by lightning during the storm at Leeds. On the 9th, a violent storm at Bourdeaux marks the rear of the cyclone. On the 6th, an explosion in a coal-mine at Charleroi, in Belgium, destroyed eight persons. The director had just inspected the mine, and was unable to account for the accident.

Colonel Reid has given the daily track of a West Indian hurricane, which was at Trinidad on the 11th of September, and reached Newfoundland on the 20th. By the 21st its centre had traversed one-fourth of the distance towards Britain; where its arrival is indicated by the unusual barometric depressions at the end of September and in the beginning of October. In Sicily, by the storm on Sept. 30, seven villages near Messina were inundated and destroyed. Fifteen persons were killed at Portici. The village of St. Firmin, near Briare, was engulphed, and 600 perished. At Melazzo and Marsala 100 persons perished by the tempest and consequent floods. Trees, houses, &c. were carried away. On the 4th of October, a gale, the worst since 1824, caused damage at Weymouth to the extent of £1000.

No explosions in coal-mines are recorded for *four months* before the arrival at Britain of this great cyclone. During its transit *five* fatal explosions occur within *eleven days*. These are,—on September 26, at West Bromwich (ten killed); Sept. 28, Bogle Hole Colliery, Clyde Iron Works, Glasgow (six killed);

Oct. 1 or 2, Littleton Hall Colliery, West Bromwich, Staffordshire (three killed; Oct. 3 (Sunday), Rainton, Durham (one man and seventeen horses killed); Oct. 6, Haigh Moor Colliery, Wakefield (three killed). *Six weeks* now succeed without explosions, so that there are *no explosions* for nearly *six months*, except the *five* explosions that occur *within eleven days* during the passage over Britain of a great revolving storm.

1846, November.—On the 19th and 20th (Plate II.) a *violent storm* caused many wrecks on the coasts of Great Britain and Ireland. The barometer begins to fall early on the 16th, and continues low till the end of the month. There were no explosions during the preceding six weeks. Two occur during this storm, viz. on Nov. 17, at Round's Green Pit, Oldbury (nineteen killed); Nov. 24th, Brough Pit, Coppul, near Chorley (eight killed).

1847, March.—The barometric curves for Greenwich and Rouen (Plate II.), show the passage of a storm from Greenwich towards Rouen, between the 17th and 27th of March. From the 25th to the 27th, a hurricane from W. to N. blew on the coast of Ireland (the rear of the cyclone). There are two explosions on the continent, viz. on March 22, at Mons, Belgium (twenty-six killed and many injured); March 23, Lagraine, Alsace (twenty-four killed and twelve burnt).

1847.—In December a well-defined cyclone passed over the British Islands. On the 1st the barometer at Greenwich stands at 30·23 and falls to 28·38, *i. e.* nearly *two inches* by the 6th (Plate V.). The wind during that time was S.W.; it afterwards shifted to W.S.W., and finally to W.N.W., when the barometer began to rise. At Rouen the barometer falls later, but rises sooner than at Greenwich, showing that Rouen was nearer the margin of the cyclone. The barometer is lowest (725·21) at Brussels on the 7th. The only fatal explosion during four months is on Dec. 6, at Haigh Pit, Lancashire; also on Dec. 7, at Rochdale Colliery, three men are suffocated by an escape of "foul air."

1850.—A cyclone appears by the curves (Plate V.) to have passed over Greenwich, Goersdorf on the Lower Rhine, and Versailles, between the 22nd and 28th of March. The news of a great colliery explosion at Mons, by which seventy-five persons were killed, reached Brussels on the 25th. It is therefore probable that it had taken place on the 23rd or 24th, just as the greatest barometric depression occurred.

1850.—On the 3rd and 4th of November, a most violent storm of wind caused vast loss of life and property in Britain. The packet-boat from Boulogne had to be run ashore at Margate. At Nottingham, Liverpool, &c., chimneys, walls, trees, &c., were blown down. At Liverpool, the ships 'Providence' and 'Arcturus' were wrecked, and twenty-five persons perished. Several other wrecks took place along the coasts.

On the 11th of November, at Houghton pit, Newbottle, twenty-six lives were lost by an explosion. It is stated that the workmen had been *apprehensive for more than a week.*

Two great storms succeed, one at the end of November, and the other in the middle of December (Plate V.), both distinguished by heavy gales, thunder-storms, wrecks, &c. I have given the barometrical curve at Greenwich for November and December, accompanied by the curves for November at Goersdorf and Versailles.

The contemporaneous explosions are on Nov. 19, Emroyd Pit, Wakefield; Nov. 25, Dawley, Shropshire; Nov. 28, Victoria Pit, Wakefield; Dec. 4, Oldham, Lancashire; Dec. 5, Wolverhampton, Staffordshire; Dec. 7, Haylock Colliery, St. Helen's; Dec. 13, Rowley Regis Colliery, Staffordshire; Dec. 14, Middle Duffryn, Aberdare; Dec. 17, Springfield Colliery, Hindley; Dec. 21, Wrexham, Denbigh.

On the Influence of the Solar Radiations on the Vital Powers of Plants growing under different atmospheric conditions.—Part III. *By* J. H. Gladstone, *Ph.D., F.R.S.*

During the course of the experiments recorded in my last Report, a number of questions suggested themselves, and were incorporated in my remarks. To the solution of some of these I have since addressed myself.

In previously examining the germination and early growth of wheat and peas under the various coloured glasses and in obscurity, more or less complete, it was thought necessary not to cover the seeds with mould, since that would have greatly interfered with the quantity of the light that surrounded them. For certain reasons also the air was allowed to remain unchanged during the whole vegetation of the plants. A number of well-defined results were obtained; but they were liable to the objection that the wheat and peas were not grown under normal conditions. I have felt it to be the more necessary to remove this objection, seeing that one of the most important results arrived at was in direct antagonism to what other observers had remarked; the result was, that "the cutting off of the chemical ray facilitates in a marked manner the process of germination, and that both in reference to the protrusion of the radicle, and the evolution of the plume." During the spring of the present year, therefore, another series of experiments was instituted upon the growth of the same plants—wheat and peas—under the same coloured and obscured bell-glasses, with this important difference, that a little garden-mould was placed on the bricks, together with the seeds, but not in sufficient quantity to cover them from the light. The bricks were sunk in the earth of a small garden attached to my residence in London; the seeds were kept well-watered, and a slight change of air was permitted. The experiment was commenced on April 3. It was thought unnecessary in this instance to keep any record of the weather; suffice it to say, that the season was generally backward, and that cold east winds prevailed during the latter part of April, which interfered with the growth of the plants materially. Owing most probably to this circumstance, the experiments now detailed were not so successful as those of the previous year; the main results, therefore, will only be recorded.

In respect to the wheat, it began, as before, to germinate most speedily in obscurity, but of the coloured glasses the blue appeared to be the most favourable to its growth; the red light seemed also advantageous. On May 18th, when the experiment was put an end to, the best developed plants were found under the obscured colourless glass.

As to the peas, they also grew best and most rapidly in obscurity. Some circumstance militated against their proper development under the colourless and coloured glasses, with the single exception that the roots had been put forth well under the blue glass. On May 18th, it was found that in the dark all the peas experimented with had put forth long roots, and most of them had grown tall plants; while under the partially obscured colourless and partially obscured yellow glasses, all the peas had grown, giving plants, which for the most part were taller, more succulent and less healthy in colour than those which, having been planted at the same time, had grown in the garden without any covering. The peculiarly beneficial effect of the calorific ray on the growth of peas was not observed in this instance.

Notwithstanding the imperfect success of this series of experiments, they give support to the view generally entertained of the efficiency of the chemical ray in facilitating germination, which, however, my previous experiments (in accordance with those made by Dr. Daubeny) directly contradict,

The cause of this contrariety might naturally be sought for in the fact that there was soil about the seeds in this year's experiment. In hopes of determining this point, and as the season was not too far advanced, the following experiments were instituted.

Two sets of the large, colourless, blue and yellow bell-glasses were taken. The one set was placed over bricks in plates filled with water, and on the bricks were simply laid, in each instance, twelve grains of wheat and eight peas, previously weighed. They were placed in a sunny situation in the garden, and the air was occasionally changed. This set, therefore, was analogous to those described in the last Report. The other set was placed in a sunny part of the garden over spots where the same number of grains of wheat and of peas, also previously weighed, had been sown in the mould. They were watered, and the air was changed from time to time.

On May 26th, that is a few days after the commencement of the experiment, the wheat and peas had begun to burst under all the six glasses. Summer weather succeeded, warm sunshine and warm showers.

The wheat on the bricks appeared to germinate first under the blue glass, and it grew more quickly there, yet not so many had shown signs of life as under the other glasses, and in about a month's time it was found that the plants were growing about equally well under all the three shades, though somewhat impeded by the luxuriant growth of the peas. On July 19th the plants that had thriven were counted, measured, removed from the bricks, allowed to dry in the air for twenty-four hours, and then weighed.

	No. of plants.	Weight.	Average weight.	Average increase on original weight.	Average length of plants.
		grs.	grs.	grs.	inches.
Colourless	3	5·5	1·8	1·1	10
Blue	2	5·5	2·7	2	14
Yellow	4	8·5	2·1	1·4	13

The wheat that was sown in mould was found on May 30th to have grown to the height of two inches under the colourless and the yellow shades, but the plants were not so tall under the blue. Some of the wheat under the yellow was remarkably fine. On July 19th, the following were the observed results, the weight being taken as before:—

	Number of plants.	Weight.	Average weight.	Average increase in weight.	Average length of plants.
		grs.	grs.	grs.	inches.
Colourless	3	20·5	6·8	6·1	20
Blue	2	6	3	2·3	14
Yellow	4	31·5	7·9	7·2	23

It is worthy of remark, that whether with or without mould, the smallest number of wheat-seeds have germinated under the influence of the chemical ray; yet they appear to have grown well under these circumstances up to a certain point, but the plant seems to have required the luminous or the calorific rays in order to profit much by the soil.

The peas that were placed on the damp bricks were found on May 30th to have put forth radicles of half an inch or upwards in length under all the glasses,

those under the blue being somewhat the longest. Presently the effect of the yellow light in causing the production of very long roots began to show itself. All the seeds germinated. On July 19th, the peas were treated as the wheat had been.

	Number of plants.	Weight.	Average weight.	Average increase of weight.	Average length of plant.
		grs.	grs.	grs.	inches.
Colourless	8	47	5·9	1·4	6
Blue	8	21·5	2·7	−1·8	9
Yellow	8	32	4	−0·5	7·5

The peas that were sown in mould began to grow equally at first, but in about three weeks' time those under the colourless glass were the shortest. They grew luxuriantly and filled the bell-glasses, but at the beginning of July the pea-plants which grew under the blue shade, and which had never thriven, shrivelled and died away. The leaves never opened properly. The following were the numerical observations made July 19th:—

	Number of plants.	Weight.	Average weight.	Average increase of weight.	Average length of plant.
		grs.	grs.	grs.	inches.
Colourless	8	98	12·2	7·7	33
Blue	...	...	......	...	...
Yellow	4	28	7	2·5	24

On comparing these last results, it is evident that whether with or without mould, the peas that grew under the blue glass display an inferiority. The peas growing in mould certainly produced the most healthy plants when they were exposed to all the influences of the solar ray, and the deprivation of the luminous principle proved fatal to them in their more mature growth, although the removal of the chemical ray had little effect.

These experiments indicate no relative difference in the actions of the three different coloured lights upon the germination of seeds, dependent on the absence or presence of soil; and they afford further confirmation of my former view, that the chemical rays rather militate against than favour the healthy germination of at least these particular instances of Monocotyledonous and Dicotyledonous plants. I remain unacquainted with the reason why the experiments of some other observers, and indeed one or two of my own, exhibit a tendency of seeds to germinate more readily under a blue glass. It may be from the more complete darkness thus produced; but the problem is evidently a difficult and intricate one, and I abstain from further conjecture.

Among the queries at the close of the last Report was the following:—"Does carbonic acid act specifically in the prevention of germination, or merely by the exclusion of oxygen?" It was thought that this might be determined by substituting that gas for the nitrogen in the air, and observing whether seeds germinated equally well in such an atmosphere. Experiments previously recorded rendered it unnecessary for me to satisfy myself again that peas and wheat would commence growing in a colourless jar of twenty-five cubic inches capacity. Such a jar was therefore filled with a mixture of four parts of carbonic acid and one part of oxygen, placed over mercury, on

the surface of which was a little water; it was placed in the garden with a sunny aspect. Mould was introduced, and some seeds of wheat and peas. After fourteen days it was found that the peas had merely split, and were black and decomposed, while the wheat showed no signs of germination, and were quite soft and decayed. An analogous experiment was made with pure oxygen gas. Both the peas and wheat germinated and grew a little, until no doubt the atmosphere of the jar was in a great measure converted into carbonic acid, when they also decayed. It appears then that carbonic acid in considerable excess has a positively injurious effect on germination.

In concluding the record of this investigation of the influence of solar radiations on the growth of plants under different atmospheric conditions, I feel very sensible of the imperfect nature of the results, and am convinced that such are the difficulties of the inquiry, that the conclusions actually arrived at must not be generalized without the greatest caution. Yet at the same time I beg to express the hope that other observers may take up some of the questions, to which I have incidentally alluded, but which still remain unanswered.

On the British Edriophthalma. *By* C. Spence Bate, *F.L.S. &c.*

Part I.—The *Amphipoda.*

Introduction.—The term *Edriophthalma* has been given by Dr. Leach and recognized by all subsequent naturalists, as applied to a legion of Crustacea that differs in several of its external characters, independently of the eyes, from that on which he has conferred the antagonistic term of *Podophthalma.*

These two applications are not capable of comprehending within their separate significations every genus which it is desirable should be so embraced. There is a whole family that belongs to the Macroural type, the eyes of which are sessile, being lodged beneath the integument of the antennal segments. This infringement, which occurs in the *Diastylidæ* *, shows us that it is not necessarily a law among Crustacea that the eyes shall be borne on footstalks whenever there is a tendency to an accumulation of the nervous ganglia into a central mass, even though that centralization be more or less imperfect.

Again, the infringement is repeated upon opposite evidence, for we perceive that the eyes may be borne on footstalks where the nervous system is divided into many separate ganglia. The genus *Tanais* among *Isopoda* has the eyes raised upon distinct pedicles, which we believe are moveable, and differ from the eyes of the *Podophthalma* only in being less club-shaped.

But ever since the time of the great Swedish naturalist, Linnæus, the relative position of the eyes has been held as a means of natural classification, distinctly separating one great family of Crustaceans from that of another; and although there are exceptions which demonstrate that the arrangement is not free from error, yet so very generally is the application correct and so easily capable of discernment, that it probably will remain a permanent mode, even should a more perfect but less readily detective system of natural arrangement be discovered.

The term *Edriophthalma* was first understood to contain all the Crustacea which were not embraced within that of *Podophthalma*, and, with the exception of the *Cirripedia*, they are still so retained in Mr. Dana's classification of

* *Cuma*, &c. of M. Milne-Edwards.

Crustacea. It therefore would embrace a large number of Crustacea, which vary considerably in their habits and forms, some of them belonging to well-organized beings, whereas others degenerate in character and descend to those which assume an insect-like appearance.

The first step therefore separated the Entomostracans; and now when we speak of the *Edriophthalma*, it is understood to be a legion intermediate between *Podophthalma* and the *Entomostraca* of recent Crustacea. But this term still conveys too wide a signification. Latreille therefore divided it into two, one of which he named *Amphipoda*, the other *Isopoda*. A third subdivision was established by the same author, that of *Læmipoda* (or *Læmodipoda**). This embraces an aberrant group of *Amphipoda*, which previously were ranked among the *Isopoda*, and must be looked upon as differing from the normal type in the rudimentary character of certain parts, rather than as possessing separate qualifications of their own, warranting their being formed into an order of equal importance to the other two, although it has been retained in this position by the profound authority of Professor Milne-Edwards.

Lamarck embraced these, together with the *Amphipoda* and *Isopoda*, as in one family.

Duméril, in his 'Zoologie Analytique,' united the *Amphipoda* with the *Stomapoda*, notwithstanding the pedunculated character of the eyes of the latter, because in each of these genera the head, he thought, was "separated from the corselet." To these united tribes he gave the name of "*Arthrocephalés*" or "*Capités*."

Desmarest, in his 'Considérations générales des Crustacés,' has adopted the order of *Læmodipoda* which Leach united with the *Isopoda*, because he thought the vesicular sacs to be "spurious" legs.

M. Blainville, in classifying Crustacea, arranged these three under the term *Tetradecapoda*, as antagonistic to that of *Decapoda*, which is synonymous with *Podophthalma*. The adaptation of the name by Blainville to the sessile-eyed Crustacea, arose from the circumstance of their possession of fourteen legs, but this characteristic circumstance is not a constant fact.

It is true, that in *Caprella* the legs are obsolete, and in *Anceus* are altered in form, though present; yet if these facts be not admitted of importance in consequence of their homological signification, then we must include them with the higher orders, for the only separation which naturally exists is the modification of the forms of certain parts homologically the same. Thus it will be found that ten-legged Crustacea exist among the sessile-eyed form, which in all other respects are nearer allied to true *Isopodes*. *Anceus* and *Paniza*, though only possessing ten perambulatory legs, approximate nearer in their structural signification to the fourteen-legged Crustacea than to that class, which the number of these legs would seem to suggest.

The term *Choristopoda*, from *χωριστὸς separate*, *πους foot*, has been lately applied by Mr. Dana, and is made synonymous by its author with the *Tetradecapoda* of Blainville, and includes the *Amphipoda*, *Læmodipoda*, *Isopoda* of authors, and the *Anisopoda* of Dana.

Perceiving no advantage in the new term over its older synonym, and fearing the result of multiplying names, it is the intention in this Report to adhere to the one most commonly used, and on that account most generally understood. We consider the second division of Crustacea as *Edriophthalma*, using it as synonymous with *Tetradecapoda* of Blainville and *Choristopoda* of Dana.

* At first Latreille placed the animals belonging to this order among the *Isopoda*, section *Cystibranches*.—(*Dictionnaire d'Histoire Naturelle.*)

Thus it will be perceived, that, instead of considering *Trilobita*, *Entomostraca*, and *Rotatoria* as orders belonging to the second division of Crustacea, as Dana has done, we take them to form natural divisions in themselves, with wider structural demarcations than exist between the *Macroura* of the first division and the *Amphipoda* of the second. This nearer approximates the system of arrangement adopted by Milne-Edwards in his 'Histoire des Crustacés.' But in his classification, Latreille's order of *Læmodipoda* is admitted to a rank of equal importance to that of the *Amphipoda* or *Isopoda*.

This, from a correct appreciation of the homological relation of the several parts, Mr. Dana (whom as a carcinologist no one appears to have surpassed in close observation) entirely ignores, and embraces the *Læmodipoda* within the order of true *Amphipoda*, making no allowance in his arrangement for their naturally aberrant departure in outward form from that group. "They are," says that author, "properly therefore *Amphipoda* with certain parts obsolescent. . . . The more essential characters are closely related to the *Amphipoda* rather than to the *Isopoda*, and are not properly intermediate, nor a new type alike distinct from both."—Vol. i. p. 11.

This author, while from anatomical reasoning he removes the *Læmodipoda* from the position in which they have been placed as a separate and intermediate order between the *Amphipoda* and the *Isopoda*, yet sees in another group, which by every previous naturalist has been ranked with *Isopoda*, a "true intermediate species between the *Amphipoda* and *Isopoda*; and if any third or intermediate group be admitted, these should (he thinks) be considered as constituting it. These species belong to the genera *Tanais*, *Arcturus*, *Leachia*, and others allied."—Vol. i. p. 11. These form the tribe or group of *Anisopoda*, the second or intermediate of that author.

By the force of similar arguments as those which are employed for the removal of the *Læmodipoda* from taking a position distinct from the *Amphipoda*, it is difficult to imagine that so acute an observer as the founder of this new group should separate it from the true *Isopoda* upon grounds so feeble as appears to us to be the case.

But on this we shall enter more at large when we report upon the British *Isopoda*, and at present only observe, that the affinity which the *Anisopoda* holds to the true *Isopoda* in all its more important characters is too close to admit of its being recognized as a distinct and separate group of equal importance. The only feature which appears to approximate it to the *Amphipoda*, the forward direction of the fourth pair of feet, can scarcely, we think, be of sufficient importance to narrow the margin between the *Amphipoda* and the *Isopoda*, there being other characters of greater importance that induce a natural separation strongly marked.

But although anatomical science will not admit the elevation of the *Læmodipoda* or that of the *Anisopoda* into distinct orders or groups equal to that of the *Amphipoda* and *Isopoda*, yet the presence of strongly defined characters, both in development of form and suppression of parts, might safely admit, with great convenience to classification, a separation of the *Læmodipoda* from the *Amphipoda* proper, and the *Anisopoda* from the *Isopoda* proper, each forming a group subordinate to their respective types; and in this Report we propose the following arrangement:—

* Classis CRUSTACEA. Subclassis I. MALACOSTRACA.

EDRIOPHTHALMA (Legio II.).

Order.	Division.	Subdivision.	Group.	Tribe.	Family.	Division.	Subfamily.	Genus.
Amphipoda	Normalia	Gammarina	Vagantia†	Saltatoria	Orchestidæ			Orchestia.
				Natatoria	Gammaridæ		1. Stegocephalides	Montagua.
							2. Lysianassides	Lysianassa.
							3. Tetromatides	Tetromatus.
							4. Pontoporeides	Sulcator.
							5. Gammarides	Gammarus.
							6. Leucothoides	Leucothoë.
			Domicola‡		Corophiidæ	Nidifica§	Podocerides	Podocerus.
						Tubifica‖	1. Cerapides	Siphonocetus.
							2. Corophiides	Corophium.
					Cheluridæ			Chelura.
		Hyperina			Hyperidæ			Hyperia.
					Phronomidæ			Phronoma.
					Typhidæ			Typhis.
	Aberrantia				Caprellidæ			Caprella.
Isopoda	Normalia.							
	Aberrantia.							

* This Table is the result of the united labour of Mr. Westwood and the author of this Report, and is the classification about to be adopted in their forthcoming work 'On the British Sessile-Eyed Crustacea'.—C. S. B.

† Which do not live in homes.

‡ Which live in homes.

§ Which build nests.

‖ Which construct tubes.

It will here be seen that it is thought preferable to abide by the older classification, which considers the *Amphipoda* and *Isopoda* as distinct orders of the second division, than as separate groups of the same order as classified by Dana; in this, we think, we are justified upon strictly anatomical reasoning, for there appears to be as great, if not a more distinct separation, between the *Amphipoda* and the *Isopoda*, than between the *Amphipoda* and the higher types of Crustacea.

This latter opinion is one on which Dana is again opposed to Edwards and the older naturalists *.

The former considers the *Isopoda* a higher type of Crustacea than the *Amphipoda*, whereas Leach, Latreille, Desmarest, Lamarck, and Edwards have each respectively placed them next, succeeding the *Stomapoda* in the descending scale.

This difference of opinion involves and necessarily opens the question of the homological relation of parts between the different orders or groups of Crustacea, the discussion of which will enable us, we hope, to see how much or little the same organs resemble each other when adapted to forms higher or lower in the scale; and their closeness or dissimilarity will enable us to approximate toward a tolerably correct estimate of the value of the unity of typical development, and thereby judge the relation which one form of Crustacea may hold to another.

The older European naturalists, and Edwards in particular, consider the *Edriophthalma* as formed upon the same general type as the *Podophthalma*; not so the American carcinologist, who affirms that "they have not a macroural characteristic, but have a body divided into as many segments as there are legs (whence our name *Choristopoda*); the antenna, legs and whole internal structure are distinct in type."—Vol. i. p. 1404.

The consideration of the structure of the *Amphipoda* is one that has little attracted the attention of either naturalists or physiologists. This remark is the more correct in relation to our own country, where, we are not aware that there has yet been published a single communication on the internal organization of this order, except a short paper on the *Caprellæ*, by Mr. H. Goodsir, in the Edinburgh Philosophical Journal for July 1842.

The labours of Montagu were mostly directed to the pursuit of objects, and the important addition of figuring and describing the outward appearances of his results. The attention of Leach was confined to describing, generalising and classifying all known species, whether the result of his own discoveries or that of others. The researches of most later writers have been extended to the elucidation of local faunas only. Dr. Thomson of Belfast read at the British Association, and published in the Annals of Natural History for 1847, a series of papers on the Crustacea of Ireland. Dr. Johnston of Berwick has during an industrious career (alas! too early

* Milne-Edwards.

Legio (II.) Edriophthalma.

Ordo I. Amphipoda.
" II. Isopoda.
" III. Læmodipoda.

Order I. Amphipoda.

Family. Gammaridæ.		Family. Hyperidæ.	
Tribus.		Tribus.	
Sauteurs.	Marcheurs.	Gammaroides.	Anormales. Ordinaires.

Dana.

Subclassis II. Edriophthalma.

Ordo I. Choristopoda.

Tribus 1. Isopoda.
" 2. Anisopoda.
" 3. Amphipoda.

Tribus 3.
Amphipoda.
Families.

Caprellidea. Gammaridea. Hyperidea.

closed) described several Scottish species. Prof. Allman, in the 'Annals of Natural History' for 1847, published a memoir on the *Chelura terebrans.*

But even on the continent the study of these animals has not been a favourite pursuit, and few naturalists have examined for themselves beyond the external form and general arrangement of structure. Hence we find that each of the few actual observers is inclined to adopt some new scheme of generalization for himself, founded on some peculiar fact more or less common to the tribe. This will continue to be the case until the anatomy and development be properly displayed, and their structure demonstrated in comparison with other known types.

The labours of the great French carcinologist are among the best known, and certainly the most recognized and appreciated of any of the systematic works on Crustacea. But the investigations of Kölliker, Müller, and the labours of Von Siebold are valuable both in interest and importance. But these have, probably from their inland position, confined their researches chiefly to the internal structure of the *Isopoda.*

Rathke's contributions to the fauna of the Crimea are not only valuable for the addition of animals from a region that has been little examined, but are noticeable for great accuracy of delineation in minute detail, which make them second to none, if not before all others, in value, for truthfulness and the close observation of the author. But Prof. Kroyer appears to have been the one of all the naturalists who has entered upon the investigation of this order in a manner which induces us to believe that he felt the importance of its close and extended observation, and his great work, entitled 'Voyages en Scandinavie, en Japonie, Spitzberg, et en Feroe,' is a labour, of which it is to be regretted Europe has so few examples.

Recently, Mr. Dana has given to the world a great work on the Crustacea as the result of his researches in the southern seas, where he was sent by the United States Government. This work, of which the plates have only been published since this paper has been in the press, will rank its author as second to no European carcinologist, and during the course of this Report, the work, though but recently obtained, will be found frequently alluded to and quoted.

In furnishing to the best of our opportunities this Report to the British Association for the Advancement of Science, we are aware of shortcomings. These chiefly arise from inability of obtaining foreign works published many years since, and others difficult to be procured. But these faults (not many or important, we hope) might have been more considerable but for the kindness of friends, who willingly supplied us with those in their possession. In this way we are indebted mostly to John Lubbock, Esq., Col. C. Hamilton Smith, C. Darwin, Esq., and J. O. Westwood, Esq.

To study the results of other observers in connexion with a British fauna, it became desirable that specimens should be obtained from as many and distant localities as possible. In pursuance of this plan, we have many valued friends to thank, and if gratitude is to be measured in proportion to liberal communications and generous supplies, then we are most indebted to our highly esteemed correspondent the Rev. George Gordon, Bernie Manse, near Elgin, for many most interesting species, among which are some that are additions to the British fauna, as well as others that are new to science.

Our kind friend, George Barlee, Esq., so well known to naturalists by his dredging results, has sent us many valuable collections from Penzance, St. Ives, and the Arran Isles. So also from the first of these localities we have

been supplied by our friend C. S. Harris, Esq., of Budley Salterton, and from Falmouth we have recently been indebted to our excellent friend J. Webster, Esq., for the results of extensive dredgings.

From the coasts of Northumberland and Durham we have received many species through the kindness of Joshua Alder, Esq. From Weymouth we have been assisted by Prof. Williamson of Manchester, and P. H. Gosse, Esq.

To our excellent friend P. T. Smyth, Esq., who not only supplied us with the result of his own industry, but frequently placed his yacht at our disposal for dredging purposes, we cannot be too thankful, since it is greatly through his means that we have been successful in obtaining a very large collection of South British species.

Mr. Boswarva, so well known in the neighbourhood of Plymouth for his knowledge and skill in preserving the marine Algæ, has frequently sent us specimens. So also has our valued friend and companion Howard Stewart, Esq., Student of Anatomy at the Royal College of Surgeons; also his brother, Mr. Charles Stewart.

George Parker, Esq., of Jersey, and recently Mr. Edwards, an industrious naturalist at Banff, and Mr. John Loughor of Polperro, and other kind friends have furnished us with what specimens accident or good fortune may have brought within their reach *.

For the purpose of identifying species with Leach's and Montagu's types we visited the British Museum, where we received every assistance and kindness from Dr. Gray and Mr. White, whose 'Catalogue of British Crustacea' has been a valuable handbook of species, and much used by us in our progress with the subject. Nor can we forget Mr. Kippist, the Librarian of the Linnean Society, who most obligingly procured for us many books of the Society which it was necessary should be consulted.

The Homologies.—In comparing the external organization of the *Amphipoda* with that of the *Macroura*, the observer is attracted by the absence in the former of the great cephalo-thoracic buckler or carapace. This in the higher tribes is the result of the exaggerated development of some of the anterior segments of the head. This loss of the carapace is also accompanied with a separation into distinct annules of the whole of the remaining portion of the animal, whilst the cephalic region, including the seven anterior segments, assumes no greater space or higher importance than any of the other individual segments.

If a careful examination of the cephalic ring be made, it will be found that there evidently are the same relative parts, without that monstrous development which in the higher types produce the carapace.

It has elsewhere been shown †, upon evidence which appears to us impossible to be misunderstood, that the anterior segments exhibited in the carapace, viz. the antennal rings, gradually diminish in importance inversely with the development of the mandibular; that whereas the former build up the larger portion of the carapace in the *Brachyura*, the mandibular segment in the lowest of the Macroura type (*Diastylis*, *Cuma*, *&c.*‡) completes, to the almost total exclusion of the anterior segments, the entire carapace. This increasing development of the anterior or cephalic segments is in accordance with the consolidation of the nervous system, and *vice versâ*, the separation of the nervous cord into distinct ganglia is coincident with a corresponding decrease in the importance of the carapace.

* In the forthcoming work on the British Edriophthalma, we shall identify the species with their habitats upon the authority of our kind friends.

† Annals of Natural History for July 1855.

‡ *Vide* paper on the British *Diastylidæ*, Ann. Nat. Hist. for June 1856.

This law, which regulates the character of the cephalic segments in the higher types, is still persistent in the *Edriophthalma*.

The nervous system below the *Stomapoda* is entirely free from thoracic consolidation, except in the abnormal class of *Cirripedia*. The cephalic region or segments belonging to the organs of consciousness is reduced to a minimum, or represented only by corresponding appendages.

In all the higher types, the antennal segments as well as the mandibular, excepting only the anomalous genus of *Squilla* and its near allies, unite to build up the carapace, the respective relation of each segment to the others differing in importance in distinct orders. This appears to be the same with respect to the cephalic ring of the *Amphipoda*, which homologizes with the entire carapace of the *Brachyura* and *Macroura*, differing from them only in degree.

In the *Macroura* the development of the mandibular segment extends back and covers the whole of the thoracic region, forming so efficient a protection as to render the completion of the dorsal portion of the thoracic segments a work of supererogation. These latter rings in the higher types become so closely compacted together, that, by diminishing their extent, they concentrate their force; whereas in *Amphipoda* the thorax is developed into seven distinct and perfect rings, while the homologue of the carapace reaches not beyond the segment which bears the first maxilliped, and this not by any extraordinary development of the posterior cephalic rings, but by the consolidation of the three segments next succeeding the mandibular into one, which supports the three posterior appendages of the mouth.

Prof. Milne-Edwards * contends that the whole of the seven anterior segments of the animal are fused together and form the first or cephalic ring.

"The exact normal relation of the shell of the head," says Mr. Dana (part i. p. 35 of his great work), "is with difficulty determined; yet the argument that this segment extends across below just anterior to the mandibles, and only here, probably holds in this group, as in the *Decapoda*, so as to show that the shell pertains either to the mandibles or second antennæ: further investigation may possibly bring out a more definite decision."

The effort in this Report will be directed, if possible, to demonstrate that the "shell of the head" is homologically the same as the carapace in the higher types, restricted according to a law of development to be a less important feature of the animal. Gradually it descends from the most perfect forms.

In *Macroura*, a distinct suture, the cervical or epimeral of M. Milne-Edwards, is visible, distinguishing the mandibular from the antennal segments. In *Brachyura* the large development of the antennal segments completes most of the carapace; in *Macroura* the mandibular ring equals, if not exceeds, the half of this structure. This change is produced in the relation of the two parts by a corresponding decrease of importance in the antennal or cephalic portion, rather than by an extraordinary enlargement of the mandibular. As we descend in the scale of Crustacea, we find that the antennal, or that portion supplied with nerves from the cephalic ganglion, diminishes in size in relation to the rest of the carapace, and that the carapace likewise itself loses its importance in relation to the entire animal.

This, which we see being carried out in the *Macroura*, *Stomapoda*, and *Diastylidæ*, where the thorax of the animal is seen gradually in each succeeding form to become less protected by the carapace, appears to reach a limit approaching the extreme in the *Amphipoda*, when the entire thorax is

* Histoire des Crustacés, vol. i. p. 20.

free; not being protected by the carapace, it ceases to possess that resemblance to an internal skeleton, which it receives in the higher types from its peculiar relation to the monstrously developed cephalic rings.

In the *Amphipoda* the upper portion or shell of the cephalic ring is constructed as in the higher types, that is, it is formed of the antennal and mandibular segments, each reduced to almost its minimum of importance.

In *Talitrus* and *Gammarus*, but most distinct in consequence of the larger size in the former, a suture, which most certainly homologizes with the so-called cervical or epimeral suture of *Macroura*, is visible, and shows that the mandibular ring perfects its inferior arch: this forms the epistome of the frontal aspect of the head.

The line of demarcation or suture which separates this segment from the anterior, traverses the lateral walls of the head, parallel with, and but a short distance above, the mandibles, after passing which it rises toward the upper surface, but loses itself in the posterior margin about half-way from the top*. In this respect it bears some analogy to the manner in which it is lost in *Brachyura*, but only in appearance, for there it was the result of a large development of the anterior segments; here both are equally unimportant. In point of fact, the connexion of the *Amphipoda* is much nearer to the *Macroura*; and if a perpendicular line of incision were made to cut away the carapace of *Astacus* just in front of the cervical suture where it exists on the top of the carapace, that is to remove the whole of the carapace posterior to that line, and perfect each ring of the thorax, but for the pedunculated eyes, the *Astacus* would be pronounced among the *Amphipoda*.

The epistome (Plate XII. fig. 1 C) appears with little doubt to be the inferior aspect of the mandibular ring (B), which is seen on the external lateral surface of the head, and which can be identified from the fact of its carrying the mandibles. This relation of the epistome to the mandibular segment is not admitted by Mr. Dana, who rather, from analogy with the higher types, than by direct evidence of the subject before him, identifies the epistome as belonging to the inferior (or external) antennal segments.

We do not think that the evidence in the higher forms bears out this assumed relation; for whilst in the *Brachyura* the two antennal segments and the mandibular, each through the arrangement of their sternal portions, unite to form the antero-oral plate, we find that in the *Macroura* their relative importance is not of equal extent. We think, that as the ophthalmic segment is itself not developed to much importance in the *Brachyura*, and is altogether lost in the *Macroura*, so we believe that the same process of annihilation of parts continues, and that in the *Amphipoda* the only segment in which the sternal portion is persistent is the mandibular. A thin partition of osseous tissue, passing perpendicular in the median line between the antennæ, less important between the superior than the inferior, may possibly represent the sternal part of each of the antennal segments respectively.

The next three pairs of appendages succeeding the mandibles are borne upon a piece which forms the infra-posterior portion of the head (Plate XII. fig. 2 K), and is probably the sternal piece of the segments belonging to the two maxillæ and the maxilliped; the dorsal portion of these segments appears to form an arch within the cavity of the head, as given in Plate XII. fig. 3, and offers a support to the stomach as well as points of attachment for muscles.

In attributing to this internal structure the high relative importance as the

* This suture, though recognized, was scarcely appreciated by us until we had read Dana's work.

homologue of the dorsal portion of the segments, of which it is a part, we think we are justified from a careful observation of its relation to surrounding parts; and it should always be borne in mind, that the relation which the internal organization bears to the external structure is the only sound way of understanding the true relation of individual parts to the whole.

In the genus *Talitrus* the appendages posterior to the powerful mandibles appear to be strengthened by an internal process on either side, which is produced until the two meet and form a ring. It is this ring that we contend to be the homologue of the three posterior segments of the cephalic division: that it is dorsal and not sternal, is demonstrated, we think, from the fact that the nervous cord passes through the hollow, though to accomplish this a considerable depression from its normal direction is produced.

Thoracic segments (*Pereion**). The seven annules which posteriorly follow the cephalic portion are in the higher order protected by the carapace. These become less so in the descending order; and in the *Amphipoda* each segment is formed into a perfect ring, analogous in appearance to the abdominal segments in *Macroura*.

The anterior of these thoracic segments differs in its position from those which are posterior, by the circumstance, that the anterior margin overrides the posterior edge of the cephalic, whereas in all the subsequent ones the anterior dips beneath the posterior edge of the annule immediately preceding, the two margins being united by a thin membrane sufficiently elastic to admit of one plate passing to a small extent beneath the next.

The several appendages supported by these segments are locomotive in their character, sometimes more perfectly perambulatory, at others adapted for climbing and grasping, under which character the two anterior are most constant in their adaptation; and the probability is that they are never used except as supplying organs to the mouth, unless to assist in climbing occasionally.

On each side of the several annules of the thorax, the *Amphipoda* are remarkable for the development of a large scaliform appendage, which Prof. Milne-Edwards, and hitherto every author after him, consider to be epimeral or side-pieces of the dorsal arch, of each respective segment, remaining unfused. These so-called epimerals we exclude from being a portion of the true segment, believing them, as we think we shall be able clearly to demonstrate in the proper place, to be the first joints or coxæ of the legs.

Abdominal segments (*or pleon*†).—The next succeeding seven rings form the so-called abdomen of all later carcinologists, but they support three very distinct kinds of appendages.

In the *Brachyura* the appendages are all of one sort, and these all present only in the female, and are adapted to a special function connected with the process of reproduction. In the male they are absent, except the two anterior pairs, which are modified so as to adapt them to fulfil the office of intromittent organs. As we descend in the scale from perfect development, we perceive that the posterior annules are constructed and arranged so as to become a tail piece, and a powerful and efficient organ it is in the *Macroura* and *Anomoura*, which enables the animal to dart or swim through the water with considerable force and velocity.

The number of segments which are arranged to complete the caudal appendage differs in separate orders. In the *Brachyura* there is but one; among the *Macroura* the two last segments are so arranged; but among

* From περαιόω, *to walk about*: pereion, part which supports the walking legs. This and the following are suggested instead of the old and incorrect synonyms of thorax, abdomen, &c.

† From πλέω, *navigo*: pleon, part which supports the swimming legs.

the *Amphipoda*, there are four so constructed as to form a tail. Of these four, three pairs are arranged upon the same type; the other, which is the extremity, or twenty-first ring, can only be contemplated in the character of an obsolete segment with its rudimentary appendages.

Thus the segments which form the abdomen support three distinct forms of appendages. Three anterior are constructed upon one type, three succeeding upon a second, and the last, which for convenience we shall designate by the name of Telson (from τέλσον, *extremity*), upon a third; or, perhaps to speak more correctly, it is a rudimentary appendage, modified upon the type of the preceding three.

Thus we perceive a singular coincidence, that the most anterior as well as the most posterior segments of the animal are annihilated and represented by their respective appendages only, a circumstance which appears to reverse the law in embryological development in this class of animals, where we find that the earliest developed parts are the anterior and posterior extremities of the animal, the intermediate segments being the result of subsequent growth.

Having compared the twenty-one segments of the crustacean type with those of the *Amphipoda*, it will next be desirable that we should see to what extent the separate parts or appendages may or may not differ from those in the other forms.

Organs of vision.—The first normal segment of the typically perfect Crustacea is represented in the *Amphipoda* by its appendages only; the eyes, which appear to be lodged between the two pairs of antennæ, are homologically anterior to the antennæ, and are supplied with nerves which are the most anterior pair given off by the cephalic ganglia.

In the higher orders the eyes are projected upon footstalks. In the *Amphipoda* they are sessile. This distinction between the two has been thought by naturalists generally to be an important signification in relation of one tribe to that of the other; hence the feature has been made available as a demarcation of distinct orders, it being taken for granted that so visible an alteration in these organs must be accompanied by considerable and important changes in other parts of the structure.

The eye in relation to the typical animal must be viewed as an appendage of the first normal segment peculiarly developed to perfect its adaptation for the fulfilment of certain requisite conditions; after the same manner, the mandibles, chelæ and feet are necessary forms for other uses.

In the *Brachyura* an ocular appendage consists of two articulations, at the extremity of which the eye is lodged, in the same manner as we might presume the hand would hold a ball, or, to give a more correct idea, be developed into a ball having power of vision.

It appears to be a law in the decreasing structural importance of Crustacea, that the segment supporting the appendages shall disappear before the appendages that it supports; thus in *Macroura* the segment has disappeared, but the eye is still borne on footstalks. In the *Amphipoda* it appears that the eye alone remains; the segment and the articulating portion of the appendage not being developed, the eye is presented so deeply within the segment succeeding, that it appears to be behind the antennæ. But its position, wherever situated, can only be to meet peculiar advantages under certain conditions. Thus in the genus *Talitrus* the eye appears to be nearly at the top of the head, while in *Erichthoneus* and some of the *Podocerides* it is carried upon a projecting inferior angle, which in some genera of this subfamily is considerably developed in advance of the head; in which position, in consequence of the insufficient depth of structure, the eye projects upon the internal surface, where it is lodged in the form of a protuberance.

In the genus *Tetromatus*, which, we believe, is now for the first time added to our knowledge, there are four simple eyes, two upon each side of the head, instead of one made up of many facets, as is usually the form of the organ in this class of animals. But this seeming anomaly appears not to be without explanation.

In the young of the *Amphipoda* the number of facets is fewer in the eye than in the adult; the number of the lenses therefore increases with growth. In the genus *Gammarus* the early numbers are eight or ten, whilst those of the adult are from forty to fifty. If we suppose that in *Tetromatus* there were but two crystalline lenses developed in the larva, a consequent arrest of development at this particular stage would limit the number in the adult to those already present in the larva, and which therefore, we think, must be looked upon rather as two distant lenses of the same eye, than as distinct organs of vision, although to external observation they assume the appearance of two separate eyes (Plate XIII. fig. 8). The coloured cornea is very distant from the lenses.

In this genus the crystalline lens is developed in the integumentary structure of which it forms a part; in this arrangement the condition of the eye differs from that of any other among the *Amphipoda*. Close observation may detect a lessened approximation of like condition in *Anonyx Holbolli*, but there only a semi-transparency, like a single small lens, exists.

The sessile character of the eyes in this order appears chiefly to rest on the pedunculated feature being absent rather than in any definite alteration of the eye itself, and by no means is it to be considered as evidence of organs of vision indicative of a lower class of animal. This we think is easily demonstrated by the fact, that in all the *Diastylidæ* the eyes are sessile and converge into a single organ; this is the case also with some of the *Entomostraca*, whilst, on the other hand, the genus *Tanais* among the *Edriophthalma*, and *Artemia* among the *Entomostraca*, have the eyes supported on footstalks in a manner corresponding with the higher types.

The internal or first antennæ.—These organs are invariably constant in the order *Amphipoda*, although in the genera of *Orchestia*, *Talorchestia* and *Talitrus*, they are so unimportant as to be little more than rudimentary appendages. They belong to the second normal segment, which in the *Amphipoda* we believe not to be developed, or, if present, fused so completely with the next succeeding, as not to be distinguished from it.

The anterior antennæ typically consist in all Crustacea of a peduncle formed of three articulations, all of which are present in the *Amphipoda*; and a filamentary appendage more or less extensively developed, and one or two secondary filaments of greater or less importance, of which latter in the *Amphipoda* there is never more than one, and that is generally rudimentary, often obsolete, and perhaps more frequently absent than present. But this secondary appendage appears to fulfil but an unimportant office even in the higher orders, whilst in the *Amphipoda* it consists of but a few short articulated joints furnished at the extremity of each with a few hairs of a form similar to others peculiar to the species.

It therefore differs from the principal filament or *tige*, as it is named by M.-Edwards, which, except in the subfamily of *Pontoporeides*, is developed to a much greater extent, and in addition to the simple hairs, is furnished with a considerable number of membranaceous cilia, which appear to be peculiar to this organ in Crustacea. The forms of these cilia vary in certain species, and will be more particularly described when it becomes necessary to consider the especial senses of the *Amphipoda*. We shall only here remark, that they appear to us to be active agents in communicating a

consciousness analogous to sound to the auditory nerve, and on this account we shall allude to them under the name of *Auditory Cilia.*

Professor Milne-Edwards considers the presence or absence of the secondary filament or palp as a circumstance of little importance, and affirms that naturally the genus *Amphitoë*, without this appendage, is extremely near to *Gammarus*, in which it exists, if they be not in the same genus*; the separation being admitted for the convenience of classification only.

But from this our experience compels us to differ. The two filaments, however unequal, homologize with those in the higher order, where sometimes a third is added, two of which are, to the extent of our present knowledge, always constant. We therefore can but view the presence or absence of this palp, however rudimentary the form in which it may exist, as demonstrative of some change in the habits or condition of the animal, which must be accompanied by structural alteration of a more or less important character. It must therefore show a separation between animals that vary in some essential conditions, even though not very visible features.

Thus it will be found upon a close examination that *Amphitoë* is separated from *Gammarus* by important essential qualities (which will be described with the animals in our forthcoming work on this subject in conjunction with Mr. Westwood). Here it is sufficient to observe, that the habits of *Amphitoë*, as well as its structure, are closely allied to those of the genus *Podocerus*, and that they both exist in a division (*Nidifica*) of the family *Corophiidæ*, which division we have thought desirable to construct, that those *Amphipoda* which live in nests of their own construction may be separated from those which live in tubes, or burrow, such as *Cerapus* and *Corophium.*

The second or external pair of antennæ.—These organs appear to us to be the most anterior appendages, which are supported in the *Amphipoda* upon a segment that is present, and which forms almost the entire cephalic region.

One of these antennæ consists typically in the order of a peduncle and a solitary filament. The peduncle consists of five articulations. In some, as the *Macroura*, there is attached a moveable scale; and in others, as the *Anomoura*, a spine exists on the basal portion of the antenna: these appear both to be represented in the larva of the *Brachyura*, and at an early period of this stage are more important than the principal appendage of the antenna itself. These secondary parts are absent in the *Amphipoda.*

The first or basal joints of this organ in the *Brachyura* are very generally fused together, and with the nearest approximating part of the calcareous skeleton of the animal; this fusion is sometimes so perfect, that no mark of distinction is apparent to distinguish the antenna from the body of the animal: this is particularly correct of the *Leptopodiadæ.* But this close union between the parts of the antenna and the body of the animal lessens with the degradation of the creature, until we find the five articulations separate from each other and distinct from the animal. This is the case in the *Macroura* as well as *Amphipoda.*

But even in this order, *Amphipoda*, in many species it is with difficulty the demarcation between the two first or basal articulations can be made out, so intimately do they appear to be connected together. From the first of these a strong tooth or spine is commonly developed, in some more importantly than in others; this denticle is the external portion of the olfactory organ, and homologizes with the olfactory tubercle (auditory of M. Milne-Edwards, Von Siebold, &c.), which is situated on the basal portion of the antenna in the *Podophthalma.*

* Histoire des Crustacés, vol. iii. p. 28.

The two first articulations, without being actually fused with the anterior integumentary tissues, are sometimes so closely incorporated with them, as to be lost, except to close analytical observation. This is the case in the family of *Orchestidæ*, which has long been described by authors as having but three articulations to the peduncle of this antenna; but the other two may be seen to exist in the upright anterior walls of the head, of which they form the largest portion (vide Plate XII. fig. 1 = H first articulation = P second = G third and fourth). A similar conclusion is *almost* arrived at by Mr. Dana (Part II. p. 848). He says, "C [answering to P in our figure], an area adjoining the antennæ, having a membranous covering and properly a part of the base of the outer antennæ; *d* [answering to H in our figure], a shelly area either side of *e* [C], or epistome*." This shelly area he has failed to perceive, equally with P, is part of the base of the outer or second pair of antennæ. These articulations are so closely impacted with the head as not to be observable to a lateral examination of the animal, being as they are absorbed into the cephalic region. It is this peculiar arrangement of organs in this family that pushes, as it were, the whole of the anterior organs to the top of the head, placing as it does a more than usual distance between them and the oral appendages.

The filamentary termination of this antenna in the *Amphiphoda* is invariably solitary and generally multi-articulate. It obtains its most filamentary character in the true *Gammari*, but in some genera the whole of the numerous articulations of which it is constructed become consolidated.

The first approximation toward the strengthening character of this organ, exists in the true *Amphitoë*, whence, by its near allies through *Podocerus*, it arrives at its fulminating point in *Corophium* and *Chelura*, where they are completely fused into a single articulation (vide Plate XIII.). In such cases they are powerful assistants in enabling the animal to climb over uneven surfaces, and probably assist in the construction of their abodes, whether burrowing, as *Chelura* and *Corophium*, or forming tubes, as *Siphonocetus* and *Cerapus*, and probably also *Erichthoneus*, or in building nests, as *Amphitoë* and *Podocerus*; and to adapt them more completely to their work, they are often supplied with hooks towards the extremity (Plate XIII. fig. 6 *a*). These are formed by the consolidation of some of the capillary armature into strong curved spines; the best examples that we have observed are in *Podocerus*, where they must become an additional means to the power of the antenna.

In all Crustacea this pair of antennæ appears persistent and generally well developed; we are not aware that there exists in any of the *Gammarina* of this order, or among the aberrant family of the *Caprellidæ*, a solitary instance of its being reduced to a rudimentary or obsolete form.

This remark appears to be true of *Isopoda* as well as *Amphipoda*, if we remove from each the parasitic forms, such as the *Hyperia* among the latter, and *Bopyrus* and its allies among the *Isopoda*; a circumstance, which induces us to believe that the second antenna is the seat of a sense which undergoes but slight modifications to enable it to be equally efficient whether in air or water, since the *Orchestidæ* live entirely out of the water, as likewise several species of *Isopoda*.

The mandibles.—These are the next succeeding appendages, but are separated from the last by the epistome and labium.

The former (epistome) is generally placed in the *Amphipoda*, vertically in the anterior wall of the head; occasionally it is produced into a spear-like

* The Plates to Mr. Dana's work having been published since this has been in the press, we have only known the references to them by the text of his work.

process, as in *Anonyx ampulla* (Kroy.); but in the more common forms it appears as a plate across the anterior portion, as if it gave strength and solidity to the structure. As before observed, this is the sternal aspect of the mandibular segment, and acts as a fulcrum to the labium and anterior portion of the mandible.

The labium is divided into two parts, the upper and the lower. The line of separation appears to be an imperfect hinge enabling the lower portion (E, fig. 2, Pl. XII.) to possess a slight opening and closing power, which co-operates with the mandibles in collecting materials into the mouth.

The margin of the labium is generally fringed with hairs. In *Gammarus gracilis* many of these are club-shaped and cumbersome in their appearance.

The mandibles are powerful organs which impinge at their extremities one against the other, the biting edge being in the median line, and developed into a series of denticles or teeth-like processes (Pl. XIV. fig. 6 *b*); these vary in form, in some considerably, and perhaps less remarkably in all genera. Within the denticulated extremity a second process commonly exists (Pl. XIV. fig. 6 *c*), like a repetition of the first. It appears not to be always present; but when it is, the plate is articulated by a free joint with the mandible, and is capable of a certain amount of movement. Situated about the centre of the posterior margin stands a large projection, which meets a fellow in the opposite mandible, and is evidently adapted for mastication; it may with propriety be called the molar tubercle (Pl. XIV. fig. 6 *a*). It forms with the anterior denticulated edge the two extremities or horns of a crescent. The second or articulated process is placed between the two, but nearer to the anterior teeth. This intermediate plate appears to be constructed so as to pass the food from one to the other, from the biting to the grinding surfaces, between which there are curved spines (*d*) to facilitate the movement.

The two mandibles are brought into contact by powerful muscles, which are attached to the inner surface of the dorsal portion of the cephalic ring, and homologize with those attached to the long calcareous tendons in *Macroura*, which have their muscles secured to the inside of the carapace.

The surface of the molar tubercle is covered over with rows of teeth-like processes, so minute that they can only be defined by a quarter-inch power object-glass. The arrangement of these teeth is tolerably constant, being in rows more or less even. At the lower portion the teeth are larger, the outer row being most conspicuous; the size diminishing, row after row, until towards the higher limits, their importance has so fallen away, that they can with great difficulty be distinguished at all. In some species there is added a filamentary appendage to this tubercle, the margin of which is ciliated with minute hairs. Perhaps this may be in some way connected with taste.

The mandibles are no exception to the general law among the Articulata, that all the appendages are modified legs; the mandible itself homologizing with the ischium or third joint of the perambulating leg, and the same in the gnathopodite of the recent acute but cumbersome homological nomenclature of Prof. Milne-Edwards, the maxilliped of authors generally.

That the third joint is the correct homologue, unless the second be fused in common with it, we think can be demonstrated by the fact, that in the *Macroura* the ischium of the third gnathopod (maxilliped) has the inner margin furnished with teeth which impinge against the similarly denticulated edge of the corresponding member, and assumes the character of a not very imperfect biting apparatus.

In the mandible of the *Amphipoda* the parts are developed into an efficient and powerful organ; the denticulated margin has the teeth more

strongly defined where their office is most required, but absent where not wanted.

In some, as *Anonyx denticulatus*, the anterior teeth are reduced to a smooth cutting edge; but we have failed to detect that any relative form is dependent upon the character or kind of food which it may be the habit of the animal to prey upon. The *Talitri*, which are known to be carnivorous, appear to differ in no important feature from those which are believed to live on marine vegetables, as is the case with the *Gammari*.

The ischium being developed into the necessary or important part of the mandibles, the remaining articulations of the typical appendage are reduced to an obsolete form, and in some of the *Amphipoda* are entirely wanting. This is the case in the family of *Orchestidæ*, a circumstance from the, at most, amphibious character of the group, which suggests the idea, that it is efficient only to those which inhabit the water, from scarcely any of which among the *Amphipoda* is it wanting, as far as our experience goes. The use of this appendage is, perhaps, to direct floating material more readily towards the mouth. The organ generally is raised and lies between the lower pair of antennæ.

The Maxillæ.—These are separated from the mandibles by a posterior labium (Pl. XV. fig. 2), which differs from the anterior in being cleft in the centre, but probably cooperates with the mandibles in the process of manducation.

The maxillæ are two pairs, the first or anterior, and second or posterior. They are extremely delicate leaf-like organs, and by no means fulfil the idea suggested by their name.

The segments of which they are appendages, together with the next succeeding, the first maxilliped, are fused together and concentrated around the mouth.

The *first maxilla* consists of three foliaceous plates (Edwards has figured a fourth in this same species, *Gam. locusta*); the basal is developed upon the second articulation or basis joint of its homological position of the leg; the coxa being, we presume, suppressed from a tendency we observe in Crustacea generally to a fusion of this articulation with the main trunk of the animal, rather than with the appendage of which it forms a part. The second foliaceous plate is developed upon the third joint or ischium in the homological character of the leg, and therefore represents the veritable portion of the mandible (Pl. XV. figs. 3, 4, No. 5). The third leaf-like plate consists of two joints, the fourth and the fifth, the meros and the carpus. This last represents the appendage to the mandibles with the anterior joint or propodos suppressed. The extremity of each plate is fringed; in the anterior or third it exists in the form of five or six short stout teeth. The middle have likewise teeth, but these are more numerous, and exist in two rows; the teeth are long, and each has the point slightly curved, having the anterior edge itself furnished with three or four smaller teeth. The first or posterior plate is furnished with a thick row of hairs, the anterior portion of which is extremely plumose and bushy.

The *second maxilla* consists of two foliaceous plates only, which latter homologize with the first and second of the anterior maxilla; they are extremely delicate and furnished on their anterior margin with stout hairs, which generally are slightly ciliated.

In the genus *Sulcator* (but whether it holds through the whole of the subfamily of the *Pontoporeides*, we have not experience to guide us) the posterior plates of both pairs of maxillæ are folded so as to become two or three parallel leaves, one of which, in the first maxilla, is developed into a

prominent lobe, the contents of which are large cells apparently of a secreting kind; but of the office or use of the organ we have met with no analogy among Crustacea to guide us.

The Maxilliped.—We here retain the older name in order to distinguish between the two next succeeding members. This is the last of the three appendages which are supported by the same ring. It homologizes with the first or anterior maxilliped in the *Macroura*, but as an operculum fulfils the duty of the third or posterior, and properly belongs to the cephalic division.

The basal joint and the next succeeding are foliaceous in their development and furnished with hairs; that of the third joint or ischium is also supplied with small denticles or teeth; these vary considerably in form, and we think may be used as a valuable adjunct to other circumstances as a test for species (vide Pl. XVI. fig. 6, No. 3, and Pl. XVII. D, fig. 1 to 5), of which advantage will be taken in the forthcoming history of Sessile-eyed Crustacea.

*The Gnathopoda**.—The (so-called) thoracic members consist of seven successive pairs, which generally throughout the *Amphipoda* are developed upon analogous types, and assume to appearance the character of organs more or less perfectly adapted for perambulation. These seven pairs represent three separate forms; the two anterior, with a few exceptions, are developed into more or less perfect prehensile organs, and homologize with the two posterior pairs of maxillipeds of the higher types of Crustacea, and like them their chief use appears to be as organs attendant upon the mouth. For the sake of distinction from the posterior pairs, we shall adopt the name given to them by M. Milne-Edwards, of gnathopoda, as being singularly appropriate for these subcheliformed organs.

In swimming, walking or climbing, unless perhaps to overcome any extraordinary difficulty, the two gnathopoda are always at rest, being folded up and overlying the external oral appendages.

Perhaps no member in the whole range of Crustacea in one order undergoes such a variety of modifications adapted to one end, more or less complete, as is to be found in the gnathopoda of the *Amphipoda*. They vary from the simple finger and thumb of the perfect chela to the rudimentary or obsolete form, in which the hairs that ornament it are more important than the impinging process itself. Sometimes the prehensile character depends upon the dactylos or finger being reflected back and impinging against the propodos, either of which may have its edge of contact simple or serrated; sometimes antagonistic to the point there is a minute denticle, a rudiment of the thumb-like process, which upon full development completes the normal chela of the higher types. The most constant position for this tooth is at the extremity of the anterior inferior angle of the propodos, to the portion between which and the articulation of the dactylos, we shall limit the signification of the palm. Occasionally the thumb is the result of an analogous development of the next succeeding joint, the carpus, as we find to be the case with *Cerapus* and *Erichthoneus*, or of the still anterior articulation, the meros, as is the case with *Lonchomeros*; in which examples the prehensile claw is formed with one and two intermediate articulations existing between the two impinging extremities.

The first of the gnathopoda is generally the less important of the two, though not invariably, as in the genus *Lembos*. It is moreover occasionally developed, as in *Talitrus* and *Lysianassa*, into a simple foot; a feature that we are not aware is ever the case with the second, which generally is the more important organ of the two. Occasionally, as in *Talitrus*, *Anonyx*, *Lysianassa*, &c., the cheliform character of the second foot is very rudi-

* This includes the two first thoracic feet of authors.

mentary; but as far as our experience goes, it is never developed into a perfectly simple foot. The nearest approach may be in *Tetromatus*.

These two pairs of members are formed most commonly upon the same type, those of the same pair are invariably alike. Once or twice we observed indications of a variety of form between those of the same pair, but these we were induced to consider as the result of an abnormal condition of the part rather than a constant feature in the species.

Even between the sexes the form of these members exhibits a very marked similarity, though the rule is not constant. We see in *Orchestia littorea* that the second pair of gnathopoda in the male are furnished with large powerful claws; whereas in the female they are scarcely more than rudimentary, and assimilate in form to those found in the larva of this species. The realization of the same may be found in a few other species, but still the prevailing rule admits of little variation even where any exists.

*The Pereipoda**, or walking feet.—The two next succeeding pairs are the first true perambulating feet, and are always developed simple in the *Amphipoda*, unless there may be an exception in the genus *Phrosina*. The first homologizes with the great claw in the *Macroura* and *Brachyura*; and both are in all the swimming *Amphipoda* less important in their peculiar character than either those which are anterior or posterior to them; but in those which use them more in walking, which include many of the *Corophiidæ*, they are larger and stronger. Their action is directed forwards, similarly to the two gnathopoda or anterior pairs of feet.

The three next pairs of legs are the last belonging to this portion of the animal, and are the powerful perambulators in *Amphipoda*; generally the last is the longest, but not invariably so; in *Phoxus* it is almost obsolete. They differ from the anterior in being directed backwards, and having each the thigh or basal joint developed into a scale-like process.

Among the more important features which are peculiar to the legs of the *Amphipoda*, and perhaps to the whole of the legion of *Edriophthalma*, and identify them as distinct from the *Podophthalma*, is, that every joint is so constructed that the whole leg can move only in its own plane. The legs of the *Podophthalma* are arranged to admit of greater freedom in their action; they can bend them in almost any direction. Independently of this peculiarity, there are others equally characteristic of the order.

The separate parts of which the leg is constructed are unequal in their respective lengths as well as different in form in the separate orders. The basal joint in *Podophthalma* is extremely short and unimportant in appearance, whereas among the *Amphipoda* it becomes perhaps the most powerful and conspicuous of any, as may be seen by reference to the table representing the homologies of the leg in Crustacea (Pl. XVI. figs. 2, 3, &c.). Moreover it is often so developed, as, when folded up, to receive the extremity of the same leg within a groove, and sometimes, as in *Acanthonotus*, the propodos is completely buried and protected from accident.

The knee or bending articulation, which admits of one portion of the leg being folded upon the other in the *Brachyura*, takes place between the meros and the carpus: in the *Amphipoda* it takes place between the ischium and meros; but the greatest individuality in the character of the legs of the *Amphipoda* proper, as well as the *Isopoda* proper, and which, we think, has led to error in the appreciation of the true position of these creatures in the class Crustacea, is to be found in the development of the coxa or first joint of the leg; the epimerals of authors generally, and Prof. Milne-Edwards in particular.

* This includes the five posterior thoracic feet of authors.

The coxa in *Brachyura* is universally fused with the segment of the body, so that its normal form cannot be distinguished; in the *Macroura* it is free: it is here we are enabled to make out that the normal number of joints in the legs of Crustacea is seven, which only vary by suppression of the last or fusion of the first with the body of the animal.

In the *Amphipoda*, except the aberrant tribe of *Læmodipoda*, the coxa is always developed into a scale-like process, and has been always considered as side-pieces complementary to the segment of the body to which the legs belonged, and received the name of epimerals or side-pieces by M. Milne-Edwards.

These so-called epimerals, we think, we shall here be able to demonstrate, are homologically the coxæ of the legs, and represent the first joint in the typical condition of Crustacea. But this is so contrary in its description to the opinions of all the highest authorities, that it is necessary we should produce good evidence of the reason why we are induced to affirm that the scale-like form belongs to the first joint of the leg, rather than to the segment, of which the leg is an appendage.

The normal number of joints is most conspicuous in *Nephrops* and *Homarus*, where the coxa is an articulating joint, but appears to have no very great extent of movement. In the *Brachyura* and the *Læmodipoda*, that is the *Aberrantia* of the table accompanying this Report, the coxa is fused with the body; but in the *Amphipoda* it is *fixed to*, but not *fused with*, the segment.

There is a peculiar tendency among the *Amphipoda* to a development of a scale-like form to the joints of the legs in general, a fact which is recognized as a constant feature in the *basis* joint of the three posterior perambulating legs.

This is occasionally the case with the same joint in other legs, as in *Podocerus*, but appears to reach a culminating point in the genus *Sulcator*, where there is a peculiar tendency to this kind of development in almost every part of the visible members.

The object of this peculiar development seems to be for the protection of the branchial organs, which are suspended from the inner surface of the legs, and would otherwise be liable to accidents, particularly to such animals as *Sulcator arenarius*, whose habitat is in the damp sand.

But the chief object which here we have to demonstrate is, that this scale-like development belongs to the leg and homologically is the first joint (or coxa), and that it is not a lateral or separate portion of the annular segments of the body of the animal, and, in fact, that no side-pieces or epimerals exist; to this end we think we are justified by the following arguments, which we shall endeavour to substantiate:—

1st. That seven joints are the normal number in the legs of all the Malacostracous Crustacea.

2nd. That the branchia is normally an appendage of the leg and attached to the coxa.

3rd. That the moveable power of the leg is always between the coxa and the leg, and never between the coxa and the body.

4th. That the coxa (the so-called epimeral) in *Amphipoda* overlaps the segment to which it is attached, and except by a small portion only, is not united by the whole of the margin in juxtaposition with the segment.

5th. That there are no epimerals where there are no legs.

6th. That epimerals are found in no other type, except the *Edriophthalma* among Crustacea.

1st. *That seven is the normal number of joints to a leg*, we think we have already disposed of, in comparing the leg of the *Macroura* type with

those of Crustacea generally, and *Amphipoda* in particular, which is better and we think fully explained in the table of the homologies in Plate XVI.

2nd. *That the branchia is normally an appendage of the leg and attached to the coxa.*—This is readily observable in the *Amphipoda*, but not so distinct in the higher types, inasmuch as the organ is developed within the walls of the carapace and possesses an internal character. But this internal character is one of appearance only, dependent upon the monstrous growth of the carapace, which covers the rings and the branchial appendages also. Therefore, whenever the anterior cephalic segments cease to be developed into a carapace or protecting buckler, the branchial organs must be external, which in reality is their homological position even in the highest developed forms.

In the *Brachyura* and *Macroura* the branchial organs are lodged in a cavity formed by the carapace, but they are separated from the great cavity containing the internal viscera by the wall of the segments belonging to the (so-called) thorax. These segments are not complete in their structure, but still they are a portion of the external skeleton, and the branchial organs developed upon their outer surface are homologically the same as the branchial sacs on the inner side of the coxa in the *Amphipoda* ; and the probability is that the disarrangement exists in the higher type, in order to meet certain conditions which enable them to fulfil the more complete function of internal gills. The typical character of the branchial organs in Crustacea is an external apparatus.

The coxa in the *Brachyura* is anchylosed with the segment of the body. In *Macroura* it is free; consequently we can the more readily perceive the attachment between it and the branchia. The flabella in the same orders, which are nothing more than an altered gill, originates from the same joint, and every fact proves to demonstration that the true homological position of the branchia is in connexion with the coxa (Pl. VIII. figs. 2, 3, 10).

Admitting then that the branchial organs are appendages of the legs attached to the coxæ, we perceive at once, since they are attached to the (so-called) epimerals, that these epimerals must homologically be consonant with the coxæ of the *Macroura* type, and therefore the first joint of each leg.

3rd. *The moveable power to the greatest degree is between the coxa and the next succeeding joint, and never between the coxa and the animal.*—This is most apparent in the *Brachyura*, where the coxa is fused with the segments of the body. In the *Amphipoda* it is not fused, but fixed, and the greatest freedom of motion to the legs is where the next joint is articulated with this, which is so frequently close to the base, that it is highly probable that a hasty examination of some of the more common species only, such as *Talitrus* and *Gammarus locusta*, might delay the acceptation of a fact urged by an unknown individual in opposition to the long-received idea propounded by the highest authorities and admitted by all others (vide Pl. XV. fig. 8). But if the very transparent and by no means rare species of *Gammarus grossimanus* be examined, the coxa will be found to have the scale-like form developed to a moderate degree only ; and unlike most of the common species, the basal joint articulates with the coxa almost at the extremity, and gives to the latter so much the character of being a portion of the leg, that if all others of the class had been the same, we doubt if any observer would have thought of describing them as epimerals or side-pieces of the true segments. This remark will also hold in relation to the three posterior legs of *Amphipoda* generally, where the coxæ are developed to a small degree; also in the group *Aberrantia* (*Læmodipoda*), where each is fused with the rest of the animal, as we find it is the case in *Brachyura*, a circumstance

which demonstrates that a fusion of the parts of the leg with the body is no evidence of a more or less perfect type of Crustacea.

4th. *That close examination shows that the (so-called) epimerals are not united to the segments in a manner which would be the case if they were merely separated parts of the same segment* (Plate XV. fig. 8).—It is but natural to suppose, whenever, in the structure of a segment, it is necessary that a line of demarcation, from incomplete union by an arrest in the development of the whole, must exist, the two separated portions would continue in the same plane. But these coxæ articulate with their segments by the length of at most one-half of the width of the segment only, and that upon the inner portion. It is this line of demarcation which splits when the animal throws off its exuviæ, and leaves the coxæ attached to the legs, a fact which shows that a closer connexion exists between the leg and the scaliform coxa than between the coxa (epimeral) and the body of the animal.

5th. *There are no epimerals where there are no legs.*

6th. *Epimerals are not observed in any except the* Edriophthalma.

These two last arguments are negative in their character; but it is at least curious, that if the coxæ are side-pieces of each successive segment, a more perfect development of the segments with the side-pieces takes place posteriorly where the perambulating legs cease to exist. Again, their absence in the *Macroura* (for we consider it a thing proved that the so-called epimerals appertaining to the carapace are in fact the mandibular segment*) is at least remarkable both in the anterior and posterior portions of the animal.

Posterior to the perambulating legs, the pleopoda or swimming-feet are attached to the underside of what is commonly called the abdomen, but which we think with more convenience may be called the pleon, being the segments which bear the swimming feet.

The superior arches of the segments overlie the side of the inferior to a considerable extent, but there are no traces of anything like independent side-pieces or epimerals.

Taking these several facts into consideration, we are forced to the conclusion that the epimerals of Milne-Edwards are not lateral pieces of the normal segment, but the first joint of the true legs, and homologize with the coxopodite of the same author in the *Brachyura* and *Macroura*.

In the *Amphipoda* the coxa is developed into a scale-like form common to the whole order, and is produced to a much greater extent in the four anterior than the three posterior legs. The three last have generally the second joint (basis) developed to assume the scaly appearance which belongs to the anterior coxa.

In some species, as in Montagua, one or two of the anterior coxæ are developed so as to hide the whole of the rest of the inferiorly situated parts of the animal.

On the microscopic Structure of the Integumentary Skeleton.

In all Crustacea, from the highest to the lowest, the composition of the tissues is the same.

From its capability of withstanding the disintegrating power of boiling potash as well as that of the mineral acids, the base of the structure is assumed to be chitine, developed in the form of cells, the hollows of which are filled with carbonate of lime.

The process of development appears to be analogous to that of the higher

* Annals of Nat. Hist. July 1855, and in Dana on Crustacea.

forms of Crustacea, but the tissue is never consolidated into so firm a structure. It seldom, except in the larger species, and in certain parts of others where strength is required, as the chelæ, &c., increases to such an extent as to cease to be transparent. This circumstance offers to the observer very valuable advantages. Without necessarily destroying life, one is enabled to perceive the currents of the circulation of the (so-called) blood; also the motion of the cardiac vessels, and the position of many of the internal organs, which otherwise could never be clearly ascertained; since in the dissection of an animal so small, a great disarrangement of the tissues must necessarily take place.

Independent of the advantage of being able to see through the dermal tissue, we are also capable of examining its minute composition, and the manner in which it is built up, without cutting the material into thin sections, and thus precluding the examination of its character as a whole. The examination of this tissue microscopically is one of considerable importance, as we believe it will be found to offer very extensive varieties of structure, the extent of which is limited only perhaps by the number of species in the genera; for as far as our examination has progressed, we have found the law of peculiarity of structure constant to every species, a circumstance in itself of great advantage in the determination of doubtful specimens.

Although a great dissimilarity of the microscopic structure between species belonging to the same genus is persistent to such an extent, as to differ widely even when the general appearances of animals assimilate so that they may be mistaken otherwise for the same species, yet we find that in different genera the character of the structure of the dermal tissue is repeated with but little modification; as compare *Gammarus* (*Othonis*?) with *Chelura* (Plate XVII. figs. 6 & 10), also *Dexamine* with *Calliope Leachii* (figs. 2 & 3) in the same table.

The closely allied species, which by Leach in his typical collection in the British Museum are arranged under the same head as *Gammarus locusta*, will be found, in spite of the very near resemblance in external character, to have a considerable variation in the microscopic appearance of the integumentary tissue, and are in fact two species, *G. locusta* and *G. gracilis*.

In *Gammarus locusta* the dermal skeleton will be found, when examined under one-fifth of an inch power object-glass, to possess a minutely granular appearance in its general aspect, studded here and there with small short arrow-headed spinules or hairs, around each of which is a semitransparent areola, it being free from granular material. In addition to the arrow-headed points, which at intervals cover the general surface, there is in this species on each side of the medial line of the four or five posterior segments of the (so-called) thorax, a row of small simple-pointed spines: these are closely placed together to the number of nine or ten in a semitransparent areola which surrounds the entire set; the whole arranged in the form of a short, rather abruptly curved line (Plate XVII. fig. 5).

The closely allied species we believe to be identical with *Gammarus gracilis* of Rathke, and perhaps also *G. Olivii* and *affinis* of Edwards, but which only a microscopic examination of the structure of the skin could positively determine, since they have been found at very distant habitats; the former at the Crimea, the latter at Naples. In this species, the most abundant upon our shores, the granular pavement is not so conspicuous; the walls of the cells, of which the tissue is constructed, are still apparent in their general arrangement. They form polygonal divisions caused by their mutual pressure. The small spinules, which in *G. locusta* assume an arrow-headed

form, are in *G. gracilis* represented by minute sharp-pointed ones, which rise out of a socket which lies within the tissue itself, and assume the form somewhat of an hour-glass, enlarging in diameter as it does at each extremity. Besides these two appearances, there is a third, which, though not present in *G. locusta*, is a feature in the order generally. This is a series of very numerous small perforations, which in some species assume a waved appearance as they come through the tissue (Pl. XVII. fig. 4).

Without being confident in the assertion, we think that the object of these tubes is analogous to that of the pores in fish and other marine animals.

In apposition to the dissimilarity, which often is very great, between the most closely allied species of the same genus, it will not unfrequently be found that the same kind of microscopic structure is repeated in species belonging to genera widely separate.

In the genus *Gammarus*, a species on our shores, which approximates nearer to that of *G. Othonis* of Edwards than any other of which we are cognisant, and has the surface rough, though minutely so, it is sufficient to be appreciable under a lens of low power. When this is examined under a microscope of greater capability, the roughened appearance resolves into a surface irregularly covered with a number of minute projecting obtuse points. These appear to have a tendency to form into rows, the unequal length as well as distance between which are so irregularly repeated, that they appear to exist often together in clusters of greater or less importance (Pl. XVII. fig. 6).

This description of the appearance under the microscope of the dermal tissue in *G. Othonis* (?) would be equally correct of *Chelura terebrans*, which belongs to a genus which bears little or no comparative assimilation with *Gammarus*, the only appreciable difference being that the points which are scattered over the surface of each are perhaps more obtuse in *Chelura*; but even this may have some modification dependent upon the part of the animal from which it is taken, or the relative ages of either (Pl. XVII. fig. 10).

Again, in *Dexamine bispinosa* of the British seas (which in form much resembles *Amphitoë costata* of Edwards from the Isle of Bourbon), we see repeated with little variety the same microscopic characters visible in *Calliope Leachii*. In each of these the animal is covered by many small scale-like processes developed upon the surface of the dermal tissue. These, attached at one margin, are raised at the opposite, which is directed posteriorly. In *Dexamine* there are also present a few solitary small hairs or minute spinules which we have not perceived in *Calliope* (Pl. XVII. figs. 2 & 3).

The scales, broad at their attached base and rounded at the apex, resemble generally a crescent form in both *Dexamine* and *Calliope*. In *Dexamine* they appear to be more numerous and generally more minute, but it is not impossible that this supposed difference may be dependent upon age or sex.

Looking at the arrangement of the microscopic structure of the dermal tissue of this order generally, we are forcibly led to rely with considerable confidence upon its value as an important test in the diagnosis of species.

The *form and structure of the hairs* which exist on different parts of the animal, when microscopically considered, will be found to be auxiliaries of analogous character; but being not so constant in their peculiarities, are less valuable as tests of species. They not only vary in species, but differ on separate parts of the same animal. In *Sulcator arenarius* there are no less than twelve varieties.

1st. Some are plain, simple, stiff, bristle-like spines. These are common,

in different degrees of strength, to the margins of the limbs generally (Pl. XVII. fig. A 1).

2nd. Are longer in general form, and are fringed on one side with a series of fine, straight teeth-like processes, assuming a rake-like character. These are attached to the maxilliped, as also another variety (Pl. XVII. fig. A 2).

3rd, Differs from the last in having the teeth bent in a curve directed to the base (fig. A 3).

4th. On the carpus of the second gnathopod (the second thoracic foot of authors), the hairs are two very distinct varieties, which appear to originate from closely approximating bases. One is long and slender, naked until the extreme point, where appear a few exquisitely delicate cilia, which give to the extremity a bulbous appearance, which can be resolved only with a 700 magnifying power (fig. A 4).

5th. The other is short, broad and flat, terminating in a point which is sharply turned upon itself; the margins of the hair are likewise furnished with a series of minute teeth pointing towards the base, ranged on each side for about two-thirds of the entire length of the hair (fig. A 5).

6th. Again, upon the same member on the propodos, we find two other forms, though decidedly moulded upon the type of the two preceding. The shorter form loses the hook-like point in a bulbous termination, and the shaft is furnished with teeth but on one edge (fig. A 6).

7th. On the appendage to the mandible a variety of this last form exists (fig. A 7).

8th. Represents the longer variety, and shows a decided increase of strength; it is slightly turned at the extremity (fig. A 8).

9th. These hairs are situated on the first gnathopod, and assimilate to No. 6 on the second in general form, but are minus the serrated margin; on one side of the extremity is a fine hair (fig. A 9).

10th, 11th, 12th are varieties of the plumose form, and are chiefly found upon the second antenna, though a few are present at several parts of the animal besides. Besides these, there are numerous modifications of a less distinct form of many of them in different positions of the animal (fig. A 10, 11, 12).

To become acquainted with the whole, so as to make the knowledge available to any practical result in the determination of species, would partake of too exclusive a study, and one that would not be commensurate to the labour entailed, if the great variety of forms were generally constant. It is not often that we meet with this obstruction.

On *Talitrus locusta* (the common shore sand-hopper).—There appears to be but a single kind of hair with but little modification of form to meet the conditions of distinct parts. They are short, stiff, blunt spines, and exhibit under the microscope a tendency to a spiral condition for about one-fourth the length of the whole from the extremity, at which distance a second, but smaller process, exists, so that the hair might be characterized as forked, but that the great inequality of the two terminations would scarcely admit the idea to be realized (Pl. XVII. fig. B). This kind of termination to the hair is by no means rare in the order. Those found in *Gammarus* are scarcely more than modifications of the same form, and not very important in their change, a circumstance which lessens the confidence in the expression of any opinion obtained from their observation.

But still the close examination of the hairs taken from positions homologically the same in different species, may not unfrequently be found an auxiliary of greater or less importance in the study of closely-allied species.

The process of moulting.—The *Amphipoda*, as all other Crustacea, renew

their integumentary tissues periodically*. This remark holds equally true as regards the lining membrane of the alimentary canal, which is cast in connexion with the external skeleton. There is no appreciable difference in the habits of the animal more immediately before the casting of the skin than at any other period. It appears to swim about just the same until the hour of moulting arrives, when it seeks a place of comparative security where it may remain the desired length of time that may be necessary without fear of interruption.

The opportunities that have been most favourable for our observations have been when the animals, confined in glass jars, have occasionally chosen a position against the upright walls.

They grasp with their anterior foot or feet some fixed ground, weed, or secure material as an anchorage, resting the entire side against the glass. Here the little creature commences its labour, which appears to be one of no great discomfort, if we may judge from the small amount of disquietude with which the operation is conducted. Almost at any stage the animal has the capability of removing, if it be disturbed, to another spot out of reach.

The process appears to be the result of an internal growth of the animal, which becoming too large for the skin, it splits. This is produced at the margin where the dorsal and sternal arches of the three anterior segments of the pereion (thorax) meet, the inferior arch carrying the legs, inclusive of the coxæ (epimerals) attached to them; a fact, which identifies, we think, the relation of the (so-called) epimerals with the sternal rather than the dorsal arch.

The first of the two gnathic segments of the pereion which overrides anteriorly the cephalic ring is broken at that point from its attachment with it, and in conjunction with the two next succeeding segments it becomes a moveable lid, as it were, to the case in which the animal resides.

After some tolerable exertion, the posterior portion of the animal, together with its limbs, is withdrawn from its normal position, and ultimately becomes entirely liberated from the skin, to which the animal now remains attached by the head and the anterior members only. A few more struggles, and the creature is free of the whole of the dead exuviæ, which is left attached to its old position.

Unless disturbed, the animal, which is now extremely soft, generally rests for some time, as if exhausted, near the cast-off skeleton; should, however, there be any cause, it is perfectly capable of swimming away immediately.

In *Caprella*, Mr. Henry Goodsir (Edinburgh Philosophical Journal, 1842) remarked that the animal, before the process commenced, "lies for a considerable time languid, and to all appearance dead. At length a slight quivering takes place all over the body, attended in a short time with more violent exertions. The skin then bursts behind the head in a transverse direction, and also down the mesial line of the abdominal surface; a few more violent exertions then free the body of its old covering. After this the animal remains for a considerable time in a languid state, and is quite transparent and colourless."

The new creature is a perfect representation of the old one slightly enlarged, and, according to our own observations, every hair is produced complete; though Prof. Edwards believes that this is not the case, but that

* Mr. Bell, in his Introduction to the 'History of the British Crustacea,' has, upon the authority of Mr. Couch, stated (in a note, page lxi), "that the families in which the eyes are always sessile in their adult growth . . . . . . do not exuviate or voluntarily throw off their limbs."

they are afterwards produced. Our observations have not been pursued upon those species which are supplied with an abundant brush of hair, but still it would appear, that if the remark be correct when the hairs are few, it would lead to the same result where they are abundant. It is certainly capable of demonstration, even before moulting, for we have repeatedly observed the new hair attached to the new skin while examining specimens under the microscope, where the second layer of similarly furnished integument is distinctly visible beneath the outer; and it has always appeared to us, though contrary to anticipation, that the new materials (hairs, spines, &c.) are not developed within each corresponding hair, spine, tooth, &c., since they are visible within the integument as a second armature.

This remark is particularly verified by the teeth on the maxillæ; this may probably be here induced by their commonly forked character, which might cause an injury, should they have to be withdrawn from similarly formed organs. This is a fate that not unfrequently happens to the branchial sacs. We have seen one of these last remain within the old tunic of the cast skin, it having been torn from the parent during the process of moulting, owing to the narrow neck of the sac; but which by analogy, we may infer, is again replaced by a process of repair, common to the whole class, but which has most frequently been observed in the higher types of Crustacea.

On the reproduction of lost parts.—The power of animals to restore to its normal character a new limb or organ, is nowhere so visibly illustrated as in this great class. The manner in which it is carried into effect has been described by Dalyell, Goodsir, and others (including a short paper of our own in the 'Annals of Natural History' for 1850, as well as the British Association Reports for the same year); but these labours have chiefly been directed to the higher orders of Crustacea, among which it has been shown, that upon the infliction of an injury upon any given member, the whole limb is immediately forcibly dislocated and thrown off. This is always done at the articulation between the coxa and the next succeeding joint.

The wound that is caused by this sudden rupture of parts is naturally stanched by a thin membrane which instantly shows itself as the immediate result, and it appears not to be impossible, that its formation, which must be very sudden, may be the amputating power.

Observers have generally added as an appendage to the above curious fact in nature, that it is exceedingly fortunate that Crustacea have this power of voluntary amputation of their members at a given spot, for otherwise, enclosed as they are in a most unyielding dermal case, they must, upon being wounded, of necessity bleed to death.

In all the natural sciences there is nothing more likely to lead to error than deductions based upon negative evidence. That an animal would bleed to death under such circumstances would appear an extremely probable hypothesis; but in answer to it, the whole of the order of the *Amphipoda* appear to want the power of the dislodgement of any of the limbs, yet they do not die upon being so wounded.

If a leg be cut off, or any part injured, the wound appears shortly after to cicatrize over with a black scar; but as far as our opportunities, which have not been inconsiderable, have enabled us to judge, the member is never thrown off.

That a limb upon being lost is capable of being reproduced, is, we believe, correct, but the injured limb is not thrown off to facilitate the reproduction.

We presume, that when the animal moults the skin, the remaining portion of the injured member may be thrown off with it, and the new limb commences reproduction at that or some earlier period; but not having been

enabled to state the circumstance from actual observation, we wish not to say much on the subject.

We have noticed a young limb commencing at the coxa as in the higher order, a circumstance which makes us infer that the reproduction of a lost member is always from that joint; and since it is necessary, before the completion of the new part, that the old one should be got rid of, it is thrown off at the period of moulting.

To meet with one of these animals with the limb undergoing the process of redevelopment is of very rare occurrence; so rare, that after having watched some thousands in glass tanks, we remember only having observed a single specimen which had two legs in this state.

On the auditory organs.—The upper antennæ are in Crustacea without doubt organs of hearing of a more or less imperfect nature. This, we think, has been argued to demonstration: first, by Dr. Farre, in the Philosophical Transactions for 1843, who reversed the decision of older authors, and gave satisfactory reasons for considering them as auditory organs in *Macroura*. This has been followed up by Mr. Huxley, who, in a paper in the 'Annals of Natural History' for the year 1851, supported the opinion of Dr. Farre by researches on some small exotic *Macroura*, and identified a "strongly refracting otolithe" in the anterior antennæ. And lately, in a paper communicated to the Fellows of the Linnean Society, and published in the 'Annals of Natural History' for July 1855, we have demonstrated a more elaborate and higher kind of organ in the basal joint of the same antenna in the *Brachyura*.

We may here therefore take for granted, since M. Milne-Edwards' 'Histoire des Sciences Naturelles' was published in 1840, in which he argues these to be olfactory organs, that the present state of our knowledge accepts the interpretation of the later observations on the subject *. Admitting this to be the fact, it is for us here merely to compare the upper antenna of the *Amphipoda* with the internal of the *Macroura*.

In *Amphipoda* the structure of the anterior antenna is very simple, and is generally long and slender. The second filament, which in the higher orders is commonly of equal length with the first, is in this order reduced to a rudimentary condition, or entirely wanting. When this antenna is reduced in length, it generally is increased in bulk at the base of the peduncle, as if the internal organization became more important with external decreasing extension. Examples of this are to be found in the genus *Lysianassa* (Pl. XIII. fig. 1) and *Anonyx*.

A marked exception to this is perceptible in the true *Orchestia*, where the organ is short and unimportant, approximating towards a rudimentary condition of the whole. This is a valuable fact, since it evidently is the result of certain altered circumstances which interfere with the proper development of the organ, which in *Amphipoda* generally is adapted for aquatic existence only.

Talitrus and *Orchestia* are in an intermediate position, their habits are between the aquatic and the land Crustacea, and are the nearest approach to terrestrial *Amphipoda* that we know. As their habits, so are their organs adapted. The Crustacea, which are purely terrestrial, possess no upper antennæ; those which are semiterrestrial possess them in but a rudimentary condition. They differ from the short upper antennæ of aquatic Crustacea, such as the *Lysianassidæ*. They are evidently impoverished organs, that is small, because they are not required; they ceased to grow from an arrest of pro-

* Von Siebold, in his recent 'Comparative Anatomy,' supports the opinion of Edwards, but we think not from his own actual researches so much as from the works of others.

gressive development. They are not the evidence of a more perfect structure.

This fact has not its full weight in the reasoning of Mr. Dana, when he makes the short upper antennæ evidence of a higher organized Crustacea.

The antenna is reduced in length to fulfil certain conditions: in *Talitrus*, because it is needless as an aquatic organ; in *Lysianassa* and its near allies, possibly as a more perfect one; in the *Hyperidæ*, with scarce an exception, on account of the impoverished character of the whole animal.

Talitrus and *Hyperia* are generally admitted by naturalists to rank at the opposite extremities of the order, and if generalization were to be adopted from a too narrow observation, then at whichever extremity of the order it was confined, the faulty conclusion would be enunciated which identifies a short anterior antenna as typical of an improved organization, and, on the other hand, one of a more feeble type.

The most perfectly formed anterior antenna belonging to the *Amphipoda* has always appeared to us to be that furnished with the most perfect and largest number of those appendages which we have in this paper denominated as *auditory cilia*, since they enable the organ more completely to fulfil its office. These membranous cilia we believe to be the external agents by which a sensation analogous to sound is conveyed to the consciousness of the animal. The imperfect nature of the organ is in accordance with our idea of the imperfect condition of the sensation conveyed to an animal so low in the scale of creation, conducted as it is by means of a medium so dense as water. We have never been able to observe any traces of an internal organ in this antenna, but in one or two species we have thought we detected a nerve traversing the lower side to the extremity of the peduncle in *Ægina longispina* and *Amphitoë rubricata*. This nerve terminates at the roots of the first auditory cilia, which are placed at the extremity of the peduncle, and are repeated throughout the length of the filamentary continuation, which appears to us to be a more or less extended base for the support of these delicate organisms. The number of auditory cilia belonging to the antenna bears no relative proportion to its length. They crowd together where the limb is short, as in Plate XIII. fig. 1. Upon the more lengthened member they generally are to be found, one at the further extremity of each small articulation.

These auditory cilia are to be found only on the principal filament in all the malacostracous divisions of Crustacea; the complementary appendage, however important, is never furnished with them. Their forms vary in different species, but not to any very considerable extent; occasionally they will be found, as fig. *c* in Plate XIII., to terminate with a little tooth-like point; very commonly they are seen with a kind of semiarticulation near the centre, as in *Tetromatus*; often they are quite simple, as in *Lysianassa*. But the most typical form appears to be blunt at the extremity, equal in breadth from the top to the bottom, with a sudden decrease near the centre, that gives it an articulated appearance. They are compressed longitudinally, instead of being round like hairs generally, and are extremely delicate in structure, quite transparent, and almost invisible when compared with the true hairs. They are membranous and flexible, and we should presume peculiarly appropriated for the reception of impressions of a vibratile character.

The concentration of these organisms upon a short antenna, together with the evident increase of diameter at the base of the peduncle, may be indications of an organ better adapted for the reception of sounds; but we have not been enabled to distinguish that there is consequently any relative increase of perfection in the organization of the entire animal.

Olfactory organ.—We have elsewhere* given our reasons for following the opinion of Dr. Farre, in transferring the seat of this sense to the lower or external antenna, in opposition to the opinions of Prof. Milne-Edwards, Von Siebold, and others. These, since they are too recent to be generally known, we shall here briefly recapitulate.

"The question which we have to consider is, to which sense either of the two sets of organs belongs;—whether the upper belongs to the auditory and the lower to the olfactory, as we shall endeavour to prove; or *vice versâ*, as maintained by all previous writers, except Dr. Farre and Mr. Huxley.

"We shall divide the evidences on either side under two heads; first, that which is derived from an external observation; and second, that which is derived from the internal organization.

"First then from external circumstances: An auditory apparatus is an organ furnished to an animal for one or both of two objects; first, for protection from danger; second, for the pleasure derivable from sounds. To animals so low in the scale of being as the Crustacea, placed as they are in a medium which must considerably modify its character, sound can convey little to the consciousness of the animal beyond a sense of security or danger.

"To enable this to be of the most extensive value, the auditory organ must be, and always is placed so as to be most exposed to external impressions at all periods; particularly when the animal is at rest or pre-occupied.

"Now if we look at the organ which the present state of science attributes to the sense of hearing, we find that in the most perfectly formed animals, the *Brachyura*, it is enclosed within a bony case and secured by a calcareous operculum; that it is always so in a state of rest, and only exposed when especially required. Not only is this the case throughout the order, but in some genera, as in *Corystes*, *Cancer*, &c., it is again covered by the supplying organs of the mouth.

"If we take into consideration the nature of sound, and its difference of character when conveyed under water from that of passing through air, the obtuse character of the former, which can scarcely be more than a vibratory action of particles of water, which conveys to us a very modified and imperfect idea of sound, we find it difficult to understand that the organ situated at the base of the under (internal) antenna is capable of receiving impressions of sound, enclosed as it is within and covered by a stout calcareous operculum.

"But if we view it as an organ of smell, every objection previously manifest now becomes evidence in favour of the idea. The small door, when it is raised, exposes the orifice in a direction pointing to the mouth; this also is the direction of the same organ in all the higher orders. In *Amphipoda* it is directed inwards and forwards. In every animal it is so situated, that it is impossible for any food to be conveyed into the mouth without passing under the test of this organ, and by it the animal has the power to judge the suitability of the substance as food, by raising the operculum at will, and exposing to it the hidden organ—the olfactory."

The deductions in the paper just quoted were the result of researches chiefly made on the *Brachyura*. In the *Amphipoda*, the homologue of the above organ, which we maintain is adapted for smelling, is to be found in the form of a small spine or denticle at the inferior side of the second antenna.

This denticle is so constant, that its absence is a thing of note, as for instance in the almost terrestrial genus of *Orchestia*; probably the result of an adaptation of the internal organ to meet a more rarefied atmosphere.

This organ appears to be developed from the first and second joints of the

* Annals of Natural History, July 1855.

peduncle; for the two appear to be so closely associated, that it is impossible to say to which it more immediately belongs. From analogy with the higher types, we should infer the first, though probably the two combine to increase the efficiency of the organ by their concentration.

In the freshwater species of *Gammarus*, the organ appears rather larger and more characteristic in form. It is from this species we shall give our description of the organ.

The first joint of the antenna is enlarged into a chamber of a globose form (Pl. XIV. fig. 4 *a*): this is received into a corresponding notch of the cephalic ring (fig. 3). From the globular chamber, which appears to be the protecting walls of an internal organ of more delicate contrivance, there proceeds a large tooth-like process (*b*), which in this Report we have called the *olfactory denticle*. It differs in length and breadth in different species, but is a very constant appendage. This process is open at the extremity (*c*), through which a tube projects (*d*), which latter is either open, or protected by a membrane too delicate to be observed, but which, from analogy with the higher orders, we are induced to believe may be the case. It is not always that the tube projects through the aperture at the extremity of the denticle; occasionally it falls short, as in *Isæa* (fig. 1); but this is merely a variety depending upon species.

The tube appears to be cylindrical, and continues internally with parallel walls to about half the length of the tooth itself, when it suddenly converges to a point, which is open, since it is entered by what appears to be a nerve, which either itself terminates in or supplies with sensibility a sharp tongue-like process (*f*), which is enclosed within the cavity of the tube-like canal. From the base of this small organ the supposed nerve is traceable in a waving line to a small bulbous origin (*g*), situated at the base of the olfactory denticle at its point of connexion with the enlarged chamber. Beyond this probable ganglion the closest investigation has not enabled us to see any further trace of the nerve.

This organ, with but little variation of external form, is to be met with in almost every species, even including those where the whole antenna is produced in the form attributable to the character of legs, and used as such in climbing over irregular protuberances of the ground.

The species in which the organ in its external form does not exist, are the *Talitri*, *Orchestiæ*, and the *Hyperiæ*, together with a species of *Gammarus*, which we believe hitherto to be undescribed; we call it in our list *Gammarus elegans*, on account of the general beauty of the form and colouring of the only specimen we have yet taken*. The lower antenna in this species is supplied with a peculiar set of organs, similar to those which have been described by Prof. Edwards in his species *G. ornatus*. Commencing on the last joint of the peduncle to the extremity of the long filament, there is, at gradually increasing intervals, a series of small membranous polyp-like bodies: they are closed sacs, and require but a low power of the microscope to perceive them. Those described by Edwards are fringed with a slightly ciliated border, and belong to a North American species, which differs in other essential respects from our British form. To assign any peculiar use to these organisms came not within the conception of their original observer, and we can only point to this solitary instance of their being present on the olfactory antenna, where the organ of the sense peculiar to it is either absent or reduced to a rudimentary character: but a more extended opportunity of observation is necessary before we can attempt to pronounce this condition constant (Pl. XIV. figs. 5 & 5 *a*).

* This may be the true reason why the olfactory denticle has not been observed: we were afraid of injuring the specimen.

In *Orchestia*, as previously observed, the absence of the olfactory denticle is probably the result of altered internal conditions of the organ necessary to meet the peculiar change of circumstances into air from water, in which the *Amphipoda* normally reside.

The denticle, when present, is situated slightly in advance of the mouth, and nothing can be eaten that does not pass the ordeal of the olfactory organs, for such we do not hesitate to call them.

Taste.—The sense of the enjoyment of food, even in the highest types of the animal kingdom, is not the result of the power of any especial organ. The nerves which communicate the idea are developed over most of the internal surface of the mouth, and it is only the consciousness of taste that demonstrates their position and use. The probability from analogy is, that the sensation is manifest to creatures low in the animal scale in a similar manner, and is rather a faculty peculiar to the mouth in general, than the result of any especial combination directed to a given part.

In *Sulcator arenarius,* and only in that species, have we observed what may possibly be an especial organ of taste. There is a large protuberance upon the first maxilla. It has a somewhat glandular appearance, and is the result of cell growth; these cells are large and nucleated. We have failed to observe the organ, or anything analogous in the same or a similar position, in any of the more common and numerous forms of *Amphipoda* that we have examined. It can scarcely be looked upon in the light of a salivary organ, although its component cells possess all the characteristics of those belonging to a secreting gland, since its position upon the maxilla, being external to the mandibles, forbids the idea. The purpose of this organ (if it be one) will require more extended and systematic observations ere it can be resolved from its present enigmatical character (Pl. XV. fig. 4 *a*).

The Prima Via.—The œsophagus leads, as in all Crustacea, abruptly from the mouth to the stomach; it is extremely short and is directed upwards, inclining rather forwards than otherwise, so that the stomach is almost entirely within the cephalic ring in the *Amphipoda.*

Just within the anterior opening of the stomach are two rake-like organs (Pl. XIX. fig. 1 *a, a*); the rows of teeth form themselves on each side into a convex line, the teeth being a little curved, the lower or anterior ones mostly so. The apparatus directs its teeth inwards and backwards, so that the food may with ease pass in, but cannot again return. The teeth on each side appear to be antagonistic sets, which probably tear and masticate the food as it enters into the stomach.

Behind this masticating apparatus there exist four simple leaf-like plates fringed with long and powerful cilia, placed in pairs (*bb*, *cc*), one anteriorly and the other posteriorly situated in the stomach; immediately above the second or posterior pair, apparently in a chamber of its own, is a gizzard-like organ (*d*). This so-called gizzard consists of several closely-packed rows of fine short strong hairs, the whole formed into the shape, when displayed, of an inverted heart with the apex removed, and the reversed section added to the base; the walls of the cavity in which the gizzard exists is lined with numerous but small hairs: the whole apparatus appears to be placed out of the direct line of continuation between the œsophagus and the alimentary canal. Posterior to the gizzard-like organ, there exists in some, but we are not certain that it is common to all the *Amphipoda*, a long *cæca* or *cul de sac* (*e, e*) on each side of the posterior opening of the stomach. These are delicate prolongations of the wall of the stomach, and gradually become narrower towards their extremity. They probably supply the stomach with a gastric juice. Still more posteriorly, at the point where the stomach con-

verges and unites with the alimentary canal, on the inferior surface, it is united with the liver.

From the stomach, the alimentary tube is continued in a direct line to the anal extremity. To this general law we know of but one exception, and that upon the authority of Professor Allman, who states that in *Chelura terebrans* the alimentary canal is so arranged as to shut one part within another to admit of the head being projected forwards, that the animal may eat its way into the wood.

In a few species the alimentary tube is continued beyond the posterior limits of the calcareous tissue of the animal, and is furnished with a slightly pectinated edge.

The most constant condition is, that the anus shall coterminate with the last segment, and is there closed by a set of transverse muscles which probably fulfil the office of a sphincter (Pl. XX. fig. 1 *c*).

The structure of the walls of the canal appears to be a membrane possessing a fibrous character which stripes it in a longitudinal direction (Pl. XIX. fig. 5). Transverse lines of a finer appearance are also perceptible (fig. 6); and the general appearance of the whole is that of a passage surrounded with elastic walls.

The stomach is retained in its position; first, by being supported upon flat calcareous plates (Pl. XII. figs. 4 O & 5), processes of the dorsal part of the segment which carries the maxillæ. These processes are flattened to receive the organ, which is further retained in its position by a calcareous continuation on each side. Besides, there are several muscles, some of which are attached to the upper external surface and retain it anteriorly, while others are attached to the under surface and hold it posteriorly in position (Pl. XIX. fig. 2, *f* & *g*).

The Liver appears to be among the most important of the viscera, if we may judge from its relative size. It uniformly, as far as our experience teaches us, consists of four long simple sacs filled with biliary cells, the contents of which are yellow in colour (Pl. XIX. figs. 3 *p*). These separate sacs unite together at their anterior extremity into a single short biliary duct, which opens into the intestinal tube on the under aspect, immediately where it leaves the stomach.

Urinary organs.—About two-thirds the distance from the stomach to the anal aperture, two long cylindrical appendages, closed at the free extremity, communicate laterally upon the upper side with the intestinal tube (Pl. XX. fig. 2). These appendages are more important in appearance in some species of *Amphipoda* than in others; but as far as our experience guides, they are universally present both in male and female, as also in the immature animal. In the younger forms they are rudimentary, as shown in fig. 4, taken from *Amphitoë*; but are scarcely more so than those found in the adult *Gammarus grossimanus*, as shown in fig. 3 of the same Plate.

Immediately posterior to the communication of this organ with the alimentary canal are a series of muscular fibres transversely lying across the latter (Pl. XIX. fig. 1 *b*); they strongly assimilate both in form and arrangement with those which we have already mentioned as being sphincter muscles, to the terminal orifice of the alimentary tube. The position which this second set of muscles holds is at the immediate point of communication between the two organs, and the general appearance would also induce us to believe that their object is to fulfil a similar office and keep compressed the efferent orifice. In fact they act the part of sphincter muscles to the urinary organ.

Although we name these the urinary organs, yet it is without perfect

assurance that we can arrive at the conclusion of their veritable purpose. But from their general position and structure, their constant presence both in male and female, old as well as young, together with the form of the entire apparatus, we are induced to believe them to be a simple form of urinary organ.

The contents, under a one-fifth power of the microscope, are resolved into small round cells, containing a nucleus of granular material (Pl. XIX. fig. 6). These cells are closely packed together, but not so firmly as to lose their original form; and the whole are confined within the walls of the organ, which appear to be very stout, the external surface of which is slightly notched (fig. 5) at tolerably regular distances, as if the organ had the power of contraction and expansion. Both the organs (if there are always two, of which we are not certain, in every species, since we have not clearly demonstrated them, except in *Sulcator*) (fig. 2) lie so closely together, as to appear like one; but in the genus *Sulcator* we have displayed them both by dissection. They lie their full length along about one-third of the upper aspect of the alimentary canal, and towards the posterior extremity make a sudden turn, and directly after connect themselves with the alimentary canal (fig. 1). The appearance of the structure at this bend is of a much more robust character than at any other point of the organ.

The Vascular System.—At the anterior portion of the alimentary canal, and placed above it, lies the cardiac vessel or heart (Pl. XXII. fig. 3 *a*). It is a long simple organ more like an aorta than a heart, reaching from the first to the last segment of the pereion (or thorax), and does not extend, as asserted in the 'Histoire des Crustacés' (vol. i. p. 98), "through the whole length of the abdomen," as is the case, upon the same authority, in the *Stomapoda*. The superior wall is suspended by a series of attachments at the centre of each successive segment, which gives it a festooned appearance through the whole length of its upper surface. The walls of the organ are of a fibrous character, arranged diagonally to the vision under the microscope, the result we believe of a spiral arrangement in the general structure of the walls. The whole possesses an elastic nature, and a persistent pulsation is carried on, causing the festoon on the upper surface to rise and fall with each successive throb.

Corresponding with the centre of each segment there is an aperture in the heart into which passes the blood, being propelled by successive jerks (Pl. XXII. fig. 3 *c*, *c*, *c*). The (so-called) blood-corpuscles are very discernible, and by this means the course of the circulation is not difficult to be traced. Though the corpuscles travel in a continuous current, yet we have never been able to distinguish that this channel is bounded by walls, in fact that there are any true blood-vessels. That none exist we think may be strongly inferred from the fact elucidated by close and continued observation of the circulation, where two currents, an arterial and a venous, travel in close proximity to each other; an occasional corpuscle from the arterial may be seen to pass over to the venous without traversing the greater circuit followed by the others.

An arterial current passes through the whole length of the animal immediately above the alimentary canal, and the great venous course returns along the dorsal centre; at the commencement of the pereion (thorax) the current appears to descend, and becomes confused to observation with the arterial channel. (Vide diagram, Pl. XXII. fig. 3.)

The legs are nourished by a single arterial current and its venous return; in the broad plates of the coxæ the arterial course passes down through the centre, where it diverges and returns as two venous currents, the one on the anterior, the other on the posterior margin. Near this point are situated

the branchial organs, where the blood, which is much divided and exposed to aëration, goes, we believe, direct to the heart, and then, without returning again to these organs, passes on its way, carrying oxygen to the general system.

The Branchiæ.—These are by no means the simple sacs that authors have universally described them. They are situated upon the inner surface of the coxæ of the leg, and assume the form of leaf-like plates on each side of the sternum, and are attached to every leg except the first in females, and generally the last in males, though in *Gammarus* we have seen them present in the male as well as the female, on the seventh, as shown in Pl. XXI. fig. 3.

The arterial course passes down on the side nearest the heart, and divides itself as it proceeds along the internal labyrinth of the organ into many streams, and passes out of the vesicle by an efferent course on the side opposite to that on which it entered.

The corpuscles never increase beyond one deep. Thus each of these supposed oxygen carriers is brought into immediate contact with the thin walls, which alone separate them from external atmospheric influences. The branchiæ homologize with the same organs in the higher orders of Crustacea, and each may be viewed in the light of a solitary plate of one of those more compound organs. In fact they bear an extremely close resemblance to the branchiæ of the *Brachyura* in the larval condition, before they assume the foliaceous appearance of the perfect organ (Pl. XVIII. fig. 10).

The great difference in the general character appears to be derived mostly from the appearance which the organs in the higher types assume of a resemblance to an internal position; but this is a condition of appearance only, as shown in an earlier portion of this paper; the branchiæ are overcapped by the monstrous production of the anterior cephalic segments, a peculiarity which is not carried out in the Amphipodous order; consequently the branchiæ are external and pendent in the water, and it is for their greater protection that the coxæ are developed into large scaliform plates.

The internal structure of the branchial organs appears to be produced by a thickening of a fibrous tissue in contact with the internal surface of the walls of the organ (Pl. XVIII. fig. 7). This appears to be carried out in patches of an irregular form, but which correspond in their arrangement with one another. These patches are thickest at their centre and thin out towards their edges: the result is that a channel is left between each. All the channels so formed are connected together throughout the whole organ, and exhibit a continuous labyrinth in which the blood circulates in many small streams (fig. 8).

Should the animal become feeble, a gradual accumulation of corpuscles may be discerned in different parts of the gills, mostly out of reach of the stronger currents, which latter, as the vitality of the animal diminishes, can be observed to lessen in force until it is propelled only by jerks, coexistent with every pulsation of the heart; and at length a throbbing without any progression of the corpuscles appears as the last effort of decaying circulation.

The external form of the organ varies but little: in *Talitrus* (Pl. XVIII. fig. 3) there appears a second of smaller dimensions, originating from a common base, the stalks being separated. Somewhat similar are they in the branchiæ of *Sulcator arenarius* (fig. 1), and would appear as if it were an effort of nature to make a step towards the more foliaceous organs of the higher types. In the *Aberrantia* we find that *Caprella Pennantii* (for in this group, except in the genus *Proto*, there are but two sets attached to the third and fourth segment of the pereion (thorax)) has the anterior branchia round and much larger than the posterior, which is more cylindrical in form.

In *Ægina* they are long and slender, and furnished on the outer side of the neck with a small articulated scale, the rudiment of the undeveloped leg (fig. 6).

Organs of Generation (*male*).—The dissection of these organs requires much care; the most distinct that we have been enabled to make out were in a specimen of *Sulcator arenarius*, sent us by our most valued correspondent, the Rev. G. Gordon, taken in Moray Frith. This specimen was so exquisitely transparent, that we could readily detect the white patch of the testes with unassisted vision; and by cautious dissection under the microscope, we were enabled to trace the connexion between them and the external organs*.

The testicles are large, opake, oblong organs, being in breadth about equal to half their length; they are situated on the dorsal aspect, immediately beneath the dermal tissues, occupying a position under the sixth and seventh segments of the pereion (thorax) (Pl. XXI. fig. 1).

From the posterior extremity of each, deflecting one to the right, the other to the left, a vas deferens proceeds towards and enters into the first joint of the seventh pair of legs (figs. 2 and 3), and again passes out and terminates in an external penis; but whether intromittent or not we have hitherto failed to discover, though we believe it is not. We have had *Gammarus gracilis* long in keeping, and watched them in their habits much; but have never detected any communication between the sexes which could admit of a direct passage of the penis into the vulva, which latter organ we have not yet discovered in the normal *Amphipoda*.

The male appears to grasp the opposite sex by one of its strong subcheliform gnathopoda, by the insertion of the claws beneath the anterior edge of the first segment of the pereion (thorax), whilst another is inserted beneath the posterior margin of the fourth or fifth. Thus grasping the female by the back, it draws it into immediate contact with the ventral surface of itself. In this attitude, more or less firmly compressed, they swim and rest alternately for days, or perhaps, as we believe, a very much longer period, without any apparent closer communication.

If the two be driven asunder by any fear of danger, as has been performed by us for the value of the observation, the female seeks a place of shelter, while the male swims more actively about; and we have noticed, that should it after a few moments swim within a little distance of its late mate, it instantly becomes aware of the circumstance, and having passed the spot, will turn abruptly back, seek her out, and seize her with avidity from amidst several others, and immediately after securing, strike her with two or three strong lashes of the tail. The female rolling herself up in fear is so carried off by her more powerful mate.

This contact between the sexes is either occasionally repeated or may last through the whole period of incubation, as we have frequently taken them coupled in this manner, even when the matured young have been sufficiently advanced as to leave the care of the parent. We are induced from this fact to believe, that a series of broods are producible from the same parents during the year, and that the erotic state of the female may exist during the incubation of any previous brood.

The penis is a soft membranous tube, the external continuation of the vas deferens, with the probable capability of erection (Pl. XXI. figs. 1, 2, 3 *a*). The orifice occupies but scarcely half of the diameter of the extremity of the tube, and most probably has the power of closing itself voluntarily. This remark is true both in *Gammarus* and *Sulcator*, in which latter the organ is

* The observations of De Siebold on this organ chiefly relate to the *Isopoda*.

considerably longer, and terminates with a simple opening near the centre of the extremity of the tube (fig. 2 *a*). In *Gammarus* (fig. 3 *a*) the orifice is on one side of the terminal point, and furnished with a small bundle of minute hairs.

The spermatozoa are long simple hair-like bodies, and bear a general resemblance to those found in the *Cirripedia*; in *Sulcator* they have their largest diameter at one end and the smallest at the other, but there is no decided enlargement of one part over the other to give it the tadpole resemblance of the typical form of these organisms. In *Gammarus*, the largest part*, if one is larger than the other, is a little on one side of the centre, with the smallest diameter equally at each extremity†.

In the *Aberrantia*, a group recognized under the generally-accepted synonym of *Lœmodipoda*, the male organs are of a more powerful character, and connected in *Caprella* with the coxæ of the last pair of thoracic legs, which in this group are all anchylosed with the segment from which they originate (Pl. XXI. fig. 4 *a*).

In the closely allied genus *Proto*, the pleon (abdomen), though rudimentary, is not so entirely obsolete; similar appendages to those which we have considered male organs in *Caprella* exist, four in number, but these homologize with the pleopoda of the anterior pleon in the normal type of *Amphipoda*.

This fact can scarcely interfere with the adaptation of the members as intromittent organs, since in the higher order of the *Brachyura* the vas deferens is known to pass directly into one of the false feet, modified for a similar purpose. The observations on this family are further supported by those of M. Rousel de Vauzeme, on *Cyamus ovalis*‡, in which the organs are situated analogous to those of *Caprella*.

Organs of Reproduction (*female*).—If we found that to become acquainted with these organs in the male required much care, those of the female demand it still more, a circumstance which will account for the incompletion of all their details with this Report; but we feel assured that which we here state may be relied upon as correct as far as it goes.

In the normal type of the *Amphipoda*, hitherto we have failed to discover the vulvæ, but infer its place from the fact of their constant position in all the higher forms of Crustacea, on the coxæ of that pair of the pereipoda or walking legs, attached to the fifth segment of the pereion; and we are induced to assign them an analogous position. In the *Brachyura* they are generally described by authors as perforations in the sternum; so they appear also in the abnormal *Amphipoda* (*Caprella*): in both these cases, as has been proved, the coxæ are fused with their supporting segments. In *Homarus*, &c., where the coxæ are free, the vulvæ are seen in their normal position, which we believe to be homologically constant in Crustacea; and those in the *Amphipoda*, probably being only oviducts in their adaptation, have escaped our observation from some slight obstruction to our plan of inquiry.

* We have observed minute objects like fat-globules attached to these thread-like organs with which they were in contact, or else form a part of the structure; a few in fig. 5 are drawn with the spots attached.

† The description given by Von Siebold in his 'Anatomie Comparée,' p. 472, § 290, agrees generally with the forms here alluded to. He says, moreover, that they are very similar in *Mysis* and the *Isopoda*. This statement is made by him on the authority of observations on *Mysis*, *Oniscus*, *Porcellio*, *Idothea*, and *Gammarus* (Von Siebold, Müller's Archives, 1836); and Kölliker has observed the same, but states them to be rigid, and not in a figure of 8, as observed by Siebold in *Iphimedia obesa* and *Hyperia medusaria*, where they are slightly enlarged and a little bent at one extremity.

‡ Ann. des Sciences Nat. 1834.

In *Caprella Pennantii* two distinct circular orifices, situated side by side, as in the highest types, are visible in the calcareous ventral aspect of the fifth segment. This is also confirmed by Rousel de Vauzeme in his observations on *Cyamus ovalis*, except the organs which he appears to raise on small prominences (Pl. XIII. fig. 17 *a,a*, Ann. des Sc. Nat. 1834). The position of these organs is very readily distinguishable, even in the dried animal, and contradicts the statement of Mr. H. Goodsir, that they are placed one before the other in the middle of the ventral region (Edin. Phil. Journ. 1842), Pl. XXI. fig. 8.

The internal organs consist of two sets of ovaries placed one on each side, but are not the simple tubes described by Von Siebold; but as that author's information consists chiefly of the results of Rathke, Brandt and Müller, who mostly pursued their researches upon the *Isopoda*, it may be that still we are both correct in the individual instances. Rousel de Vauzeme figures them in *Cyamus ovalis* of the same simple character as described by Siebold, terminating each posteriorly in a short oviduct.

The ovaries in *Gammarus* appeared to us to consist of four or five sac-like organs, narrowing each towards their attachment with a canal into which they all empty themselves in succession, the largest being the most distant from the extremity approximating the vulva. One of these sets was found upon each side of the alimentary canal, and appeared to be enclosed within a common sac; that is, we observed a transparency around the whole organ which induced us so to interpret the appearance, though we were unable to dissect the organ out, or trace it in continuation with the as yet to us undiscovered vulva.

It is not certain at what time the impregnation of the ovum takes place by the fertilizing spermatozoa, and it is only conjecture that induces us to assume it must be as the former escapes from the oviduct. Thus, if we are correct in our deduction from negative evidence, that an intromission of the male organs does not take place, then we must conclude that the male emission must escape into the surrounding medium, and that of the many thousand active organisms, some are attracted by the force of the continued currents, induced by the swimming feet, into the incubatory pouch, where they are brought into contact with and impregnate the recently deposited ovum, which after fertilization continues in this position to be cherished until after the larva quits the egg. The supposition that impregnation is an external act is supported by the observations of Von Siebold (p. 472 of the work already quoted), that the spermatozoa continue rolled into a figure of 8 until they come into contact with the water.

The Incubatory Pouch is the result of the folding over of several lamelliform plates, generally fringed with hairs. One of these is developed upon the inner side of each of the two pairs of gnathopoda and the two anterior pereipoda (or four anterior pairs of thoracic feet). These plates overlie each other in a compact form, and securely protect the eggs or the immature young from external accidents (Pl. XVIII. fig. 11).

This lamelliform appendage, which is called the palpe by M. Milne-Edwards, is, according to Von Siebold (p. 476), developed at the "époque du rut," and afterwards again disappears. This we have not been able to verify, since we have frequently taken the female at all periods of the year with these appendages fully developed, but do not recollect ever having seen them in a half-formed state. We have never observed them present on the young animal, so that probably they may be produced as the animal arrives towards the era of female development. But we are inclined to doubt, when once developed, that they ever again disappear except as the result of accident.

On the Development of the Young.—The length of time between the epoch of the deposit of the ovum to that of the emancipation of the young animal from the care of the parent, has not, as far as we are aware, been ascertained, but from parallel circumstances in *Asellus*, among the *Isopoda* it appears to last from about a month to six weeks.

At first the egg is perfectly round in form; it shortly increases in length, assuming a larger proportion at one extremity than the other; it is now that the young animal is seen under development, and indistinct segments are observable. The wall of the ovum is formed of an elastic membrane which corresponds to the movement of the internal embryo.

It is probable, that about the middle of the period of incubation, the young animal quits the egg, for we have constantly taken them from the pouch, bearing an embryonic character without being closed in their egg-case. The larva at this period is very immature and covered in a general tunic, which, apparently without having any absolute vital connexion with the animal more than the original egg-case had to the embryo, adapts itself in form to the whole creature, and fulfils the duty of a protective tissue. This probably is shed more than once, as we perceive that as the animal increases in size and completeness of form, so the tunic corresponds in its general adaptation; and at last the larva frees itself from this case and strengthens in its own development, but appears not to quit the care of the parent immediately. We have often observed that the young escape from the mother if she be taken or alarmed; from the active state of their existence at this time, they appear as if they had long since been capable of so acting if they had preferred or circumstances required it. Repeatedly observing this fact, we have been induced to believe that they had the power, and used it, of quitting the parent occasionally, and either returned to the pouch again, or else being free, continued more or less perfectly under her protection. This trace of parental affection receives support from the observation of Mr. Henry Goodsir*, who "on one occasion, while examining a female *Caprella* under the microscope, found that her body was thickly covered with young ones; they were firmly attached to her by means of their posterior feet, and were resting in an erect posture, waving about their long antennæ with great activity." But although the resemblance to the parent is very considerable, yet it is by no means complete, and it is probable that several moults are undergone before the perfect development of the animal is matured. The value of the relative difference is important, since the observation of the same animal at different stages of its existence might otherwise lead to the misinterpretation of the value of species.

When the young of *Gammarus gracilis* first appears as an animal, dependent upon its own resources, there is no very decided contrast between the articulations of the peduncle of the antenna and those which pertain to the filament. The latter itself is shorter, consisting of five articulations only, than in the mother, where there are twenty-nine; and we counted thirty-five in a male of the same species; again, in the inferior antenna there are but three joints to the filament, whilst in the adult male and female sixteen are developed. This relative difference is likewise constant in the small filamentary appendage of the upper antenna, which in the larva has but two segments of an unequal length; in the adult there are six or more.

Again, in the structure of the eye we see the same gradual increase still goes on after the young has become free. The facets, or rather lenses, which are seen beneath the integument of the animal (for we consider that the eye has no especial dermal covering peculiar to itself in *Amphipoda*),

* Edinb. Phil. Journ. 1842.

are in the young from ten to twelve in number, whereas in the adult from sixty to eighty can be counted, and the cornea assumes a deeper tint; being crimson in the larva, it becomes purple or almost black in the adult.

The young are generally of a more or less deep orange colour; in some species they are cornuous and transparent; and in the development are generally less marked than the adult.

The large hand in *Orchestia* holds in the larva a nearer contrast to that of the female than to the larger claw of the male; it is therefore extremely probable that this organ likewise increases in growth; a fact also remarked by Rathke*, regarding the warty development of the posterior leg of the same animal which still goes on with increasing age.

In *Hyperia* the larva bears so little resemblance to the parent, that it has been pronounced by Edwards, who first observed the fact, and Mr. Gosse, to be a metamorphosis; but since, even in the higher types, the immense variety of change from the *Zoë* to the adult animal is but the result of subordinate becoming more important parts, together with development of others not yet present, and therefore hardly acceptable under the signification of metamorphosis, as understood in true Insecta; we can scarcely subscribe to the great alteration of form as a metamorphosis in *Hyperia*, which is one of degree only, and of which we shall give a figure in the forthcoming 'British Edriophthalma.'

On the Nervous System.—This part of the subject has been attended to with more care than perhaps any other part of the animal, by MM. Audouin and Edwards, in a memoir published by them on the nervous system of Crustacea generally.

To this paper, which has been made the standard of all authors, we shall now refer the reader; and in this Report only draw attention to particular details of more or less importance, which we have noticed from actual observation in dissections made upon *Talitrus locusta*, and which are given in our figures of the nervous system of that Amphipod in Pl. XXII. accompanying this Report.

The scheme of the arrangement is peculiarly annular, perhaps typically crustacean; a ganglion corresponds to every segment of the animal, each being united to the other by two cords, which correspond, but are not connected with each other. From each ganglion on the right and left, a double branch is given off; the one passes to the legs, the other probably to the branchial organs. In the male, the ganglion corresponding with the seventh segment of the pereion (thorax), which supports the male organs, appears a little larger than the others. From the cords intermediate between the ganglia originates on the external side of each a corresponding nervous thread, which again divides into two, and probably supplies the internal viscera of the animal. These threads have not been recorded in the memoir quoted as belonging to the *Amphipoda*, but analogous ones are figured in the 'Histoire des Crustacés,' pl. 11. figs. 3, 4, as belonging to the *Stomapoda*. But a more important variation in the nervous system of the *Amphipoda* exists in the arrangement of that part which belongs to the cephalic region. The first ganglion (Plate XXII. fig. 2 E) of the pereion (thorax) rests upon the sternal portion of its own segment, from which anteriorly a sudden depression takes place to the infra-œsophageal ganglion (B), which lies beneath a calcareous arch (O), which earlier in this paper has been described as being the dorsal aspect of the three segments, which fused together support the maxillæ and maxilliped.

From the infra-œsophageal ganglion several nerves originate to supply

* Faunen de Crim. Phil. Trans. St. Petersburg.

the attendant appendages of the mouth, and two more important ones are directed anteriorly to the supra-œsophageal or cephalic ganglion, which last we have not satisfactorily made out, although we have traced the nervous cord almost to its connexion with it, that is, up to the anterior or facial wall of the head.

The probability is, that there is no very great amount of difference from that which is figured by Edwards and Audouin as belonging to the *Amphipoda* proper, or as given by Rouzel de Vauzeme, as observed in the aberrant genus of *Cyamus*.

Any observations, either on the generalization or geographical distribution of the order, we shall reserve until we furnish the second part of the Report 'On the British *Isopoda*,' and here only remark that our experience induces us to consider the *Amphipoda*, inclusive of the aberrant group, as a modification of the great Crustacean type, as exemplified in the *Macroura*, rather than as possessing a perfectly distinct characteristic, as asserted by Mr. Dana. In this conclusion we approximate that already arrived at by Edwards in his 'Observations on the Classification of Crustacea' (Ann. des Sci. Nat. vol. xviii. n. s. p. 121). But he includes in his remarks the *Isopoda* and the *Pycnogonides*, with which in this Report we have nothing to do.

In the accompanying Table the species are arranged according to order. Those which are in italics have never been previously recorded as British. Those marked with an asterisk, are species which we have not examined, and record upon the authority of previous authors.

Order I. AMPHIPODA.

Group A. NORMALIA.

Division A.A. GAMMARINA.

Subdivision A.A.a. *Vagantia*.

Tribe *a.a.* SALTATORIA.

Family **Orchestidæ**.

Genus.	Author.	Species.	Author.
Talitrus	Bosc.	locusta	Latr.
Orchestia	Leach.	littorea	Leach.
		Deshayesii	Audouin.
Allorchestes	Dana	*Danai*	mihi.
		imbricatus	mihi.
Galanthis	mihi	*Lubbockiana*	mihi.

Tribe *b.b.* NATATORIA.

Family **Gammaridæ**.

Subfamily I. STEGOCEPHALIDES.

Montagua	mihi	monoculoides	Montagu.
		marinus	mihi.
		pollexianus	mihi.
		dubius	mihi.

Subfamily 2. LYSIANASSADES.

Genus.	Author.	Species.	Author.
Lysianassa	Edwards	*Costæ*	Edwards.
		Audouiniana	mihi.
		Chausica	Edwards.
Scopelocheirus	mihi	*breviatus*	mihi.
Anonyx	Kroyer	*Edwardsii*	Kroyer.
		minutus	Kroyer.
		ampulla	Kroyer.
		Holbolli	Kroyer.
		denticulatus	mihi.
Amanonyx	mihi	*Guerinianus*	mihi.

Subfamily 3. TETROMATIDES.

Tetromatus	mihi	*typicus*	mihi.
		Bellianus	mihi.

Subfamily 4. PONTOPOREIDES.

Westwoodea	mihi	*cæculus*	mihi.
		carinatus	mihi.
Phoxus	Kroyer	*Kroyerii*	mihi.
		plumosus.	
Sulcator	mihi	arenarius	mihi.

Subfamily 5. GAMMARIDES.

Darwinea	mihi	*compressus*	mihi.
Iphimedia	Rathke	*obesa*	Rathke.
Acanthonotus?	Owen	*Owenii*	mihi.
Dexamine	Leach	spinosa	Montagu.
		bispinosa	mihi.
		Gordoniana	mihi.
		fucicola	Edwards.
Calliope	Leach (MS.)	*Leachii*	mihi.
Isæa	Edwards	*Montagui*	Edwards.
Lembos	mihi	*Cambriensis*	mihi.
		Damnoniensis	mihi.
		versiculatus	mihi.
		Websterii	mihi.
Lonchomerus	mihi	*gracilis*	mihi.
Eurystheus	mihi	*tridentatus*	mihi.
Amathia	Rathke	*carinatus*	Rathke.
Gammarus	Fabr.	*Sabinii*	Leach.
		carinatus?	Johnston.
		locusta	Fabr.
		fluviatilis *	Edwards.
		pulex	Fabr.
		gracilis	Rathke.
		camptolops	Leach.
		palmatus	Montagu.
		marinus	Leach.
		longimanus	Montagu.
		brevicaudatus	Edwards.
		grossimanus	Montagu.
		elegans	mihi.

Genus.	Author.	Species.	Author.
Gammarus ..	Fabr.........	*Othonis?*	Edwards.
		maculatus? ..	Johnston.
		subterraneus*.	Leach.
Niphargus* ..	Schiödte	Stygius*......	Westwood.
Thersites	mihi	*Guilliamsonia*	mihi.
		pelagica	mihi.

Subfamily 6. Leucothoides.

Leucothoë....	Leach	articulosa	Leach.

Subdivision B.B.b. *Domicola.*

Family 1. Corophiidæ.

Division A. NIDIFICA.

Subfamily Podocerides.

Pleonexes	mihi	*Gammaroides*..	mihi.
Amphitoë	Leach	rubricata	Montagu.
		littorina......	mihi (punctata, Johnston).
Sunamphitoë..	mihi	*hamulus*......	mihi.
		conformatus ..	mihi.
Podocerus	Leach	pulchellus	Edwards.
		pelagicus	Edwards.
		punctatus	Edwards.
		variegatus	Leach.
		falcatus	Montagu.

Division B. TUBIFICA.

Subfamily 1. Cerapides.

Erichthoneus..	....	difformis.	
Siphonocetus..	Kroyer	*Kroyeranus* ..	mihi.
		crassicornis ..	mihi.
		dubius	mihi.

Subfamily 2. Corophiides.

Cyrtophium ..	Dana	*Darwinii*	mihi.
Corophium ...	Latr.	longicorne	Latr.

Family Cheluridæ.

Chelura.......	Philippi......	terebrans	Philippi.

Division B.B. HYPERINA.

Family 1. Hyperidæ.

Hyperia......	Latr.	Galba.........	Montagu.
		oblivia........	Edwards.
Læstrigonus*..	Edwards	*Fabreii*	Edwards.

Family 2. Phronomidæ.

Phronoma	Latr.	sedentaria	Latr.

Family 3. Typhidæ (? British).

Typhis	Risso........	nolens*	Johnston.

Group B. ABERRANTIA.

Family Caprellidæ.

Genus.	Author.	Species.	Author.
Proto	Leach	pedata	Leach.
		Goodsirii	mihi.
Ægina	Kroyer	*longispina*	Kroyer.
Caprella	Lamarck	linearis	Latr.
		lævis*	Goodsir.
		acanthifera	Leach.
		acutifrons	Desm.
		phasma	Latr.
		tuberculata*	Goodsir.
		lobata*	Müller.
		Pennantii	Leach.
Cyamus	Latr.	ceti*	Linnæus.
		ovalis*	Rouss.
		gracilis*	Rouss.
		gracilis*	Gosse.

Reference to Drawings.

PLATE XII.

Fig. 1. Head of *Talitrus locusta*, frontal aspect.
Fig. 2. Head of ditto, lateral aspect.
Fig. 3. Head of ditto, posterior.
Fig. 4. Head of ditto, interior labial.
- A. Inferior antennal segment.
- B. Mandibular segment.
- C. Epistome or inferior portion of B.
- D. Upper division of labium.
- E. Lower division of labium.
- F. Upper antenna.
- G. Lower antenna.
- H. First articulation of lower antenna.
- P. Second articulation of lower antenna, represented by membrane with calcareous margin.
- I. Mandible.
- K. Inferior portion of the thin posterior segment of the cephalic region.
- O. Internal portion of the last segment, (the homologue of the dorsal part): on this the stomach rests.
- L. First maxilla.
- M. Second maxilla.
- N. Maxilliped.

Fig. 5. The part O seen from above.

PLATE XIII.

Fig. 1. Superior antenna of *Lysianassa*.
- *a, b, c*. Varieties of auditory cilia.

Fig. 2. Inferior antenna of *Talitrus locusta*.
Fig. 3. Inferior antenna of *Chelura terebrans*.
Fig. 4. Inferior antenna of *Sulcator arenarius*.
Fig. 5. Inferior antenna of *Corophium longicorne*.
Fig. 6. Inferior antenna of *Podocerus*.
Fig. 6*a*. Inferior antenna, the point of *Podocerus*.
Fig. 7. Inferior antenna of *Hyperia Galba*.
Fig. 8. Eyes of *Tetromatus*.

PLATE XIV.

Fig. 1. Olfactory organs or base of inferior antenna in *Isæa Montagui*.
Fig. 2. Olfactory organs of *Gammarus gracilis*.
Fig. 3. Olfactory organs of *Gammarus pulex*.
Fig. 4. Olfactory organs of ditto, enlarged.
Fig. 5. Olfactory organs? of *Gammarus elegans*.
Fig. 5*a*. Two of the segments enlarged.
Fig. 6. Mandible of *Talitrus locusta*.
Fig. 7. Mandible of *Anonyx*.
Fig. 8. Mandible of *Gammarus gracilis*.
- *a*. Molar tubercle.
- *b*. Incisive edge.
- *c*. Secondary edge with moveable joint.
- *d*. Hairs or ciliated spines.
- *e*. Muscles.

Fig. 9. *Dexamine spinosa*.

PLATE XV.

Fig. 1. Anterior labium of *Gammarus locusta.*
Fig. 2. Posterior labium of ditto.
Fig. 3. First maxilla of ditto.
Fig. 4. First maxilla of *Sulcator arenarius.*
Fig. 5. Second maxilla of *Gammarus locusta.*
Fig. 6. Maxilliped of ditto.
Fig. 7. Two segments from *Isæa Montagui,* showing their mode of attachment.
Fig. 8. Inside of the coxæ from *Gammarus,* showing the manner of their connexion with the legs and to the segments of the body.

PLATE XVI.

Diagrams showing the homologies of separate parts.

Fig. 1. Imaginary *Amphipoda.*
- A. Cephalic ring or region.
  - *a.* Anterior portion, or infra antennal segment.
  - *b.* Posterior portion, or mandibular segment.
- B. Pereion, or portion carrying the pereipoda or perambulatory legs. Thorax of authors.
- B1. Anterior portion, bearing the two gnathopoda.
- B2. Posterior portion, bearing the five pereipoda.
- C. Pleon, or portion carrying the swimming feet (abdomen of authors).
  - C1. Anterior portion.
  - E2. Posterior portion.
    - 1. Superior antenna.
      - *c.* Auditory cilia.
    - 2. Inferior antenna,
      - *a.* Olfactory denticle.
    - 3. Mandible.
      - *b.* Mandibular filament.
    - 4. First maxilla.
    - 5. Second maxilla.
    - 6. Maxilliped.
    - 7, 8. Two gnathopoda.
    - 9, 10. Anterior pereipoda.
    - 11, 12, 13. Posterior pereipoda.
    - 14, 15, 16. Anterior pleopoda.
    - 17, 18, 19. Posterior pleopoda.
    - 20. Telson (extremity).

Fig. 2. Leg of *Macroura,* after Edwards.
Figs. 3, 4, 5. Legs of *Amphipoda.* The lines drawn through each joint demonstrate the homologies.

PLATE XVII.

Microscopic Sections of the Skin and Hairs.

SKIN OF

1. *Talitrus locusta.*
2. *Dexamine bispinosa.*
3. *Calliope Leachii.*
4. *Gammarus gracilis.*
5. *Gammarus locusta.*
6. *Gammarus Othonis?*
7. *Galanthis Lubbockiana* (leg).
8. *Tetromatus typicus.*
9. *Lembos Damnoniensis.*
10. *Chelura terebrans.*
11. *Amphitoë littorina.*
12. From thorax of 7.

HAIRS OF

A. *Sulcator arenarius.*
- 1. On legs, &c.
- 2. On maxilliped (3rd joint).
- 3. On maxilliped (5th joint).
- 4, 5. On carpus of gnathopoda.
- 6. On propodos of gnathopoda.
- 8. On propodos of gnathopoda.
- 7. On mandible.
- 9. On propodos, 1st gnathopoda.
- 10. On antennæ, &c.
- 11. On superior antenna.
- 12. On inferior antenna.

B. Hair from *Talitrus.*
C. Hairs from *Tetromatus.*
D. Teeth from maxilliped of species.
- 1. *Talitrus locusta.*
- 2. *Anonyx denticulatus.*
- 3. *Anonyx Holbolli.*
- 4. *Tetromatus typicus.*
- 5. *Tetromatus Bellianus.*

PLATE XVIII.

Organs of Respiration.

Fig. 1. *Sulcator arenarius.*
Fig. 2. *Gammarus locusta.*
Fig. 3. *Talitrus locusta.*
Fig. 4. Neck of 2, showing a tendency to a more leaf-like structure.
Fig. 5. *Caprella.*
- *a.* Anterior.
- *b.* Posterior.

Fig. 6. *Ægina longispinosa.*
Fig. 7. Internal structure of branchial sac, side near the middle.
Fig. 8. Ditto, from bottom of sac.
Fig. 9. Blood-corpuscles.
Fig. 10. Leg and branchia of young Decapod.
Fig. 11. Diagram showing the arrangement of the plates which form the incubatory pouch and the position of the branchial sacs.

PLATE XIX.

Alimentary Canal.

Fig. 1. Stomach of *Talitrus*, seen from above.
Fig. 1*a*. Œsophagus from *Tetromatus*.
Fig. 2. Stomach of *Sulcator*, lateral view.
Fig. 3. Stomach of *Gammarus* in situ, with the liver attached.
Fig. 4. Alimentary tube of *Sulcator arenarius* below the stomach, with the liver and urinary sacs attached.
Fig. 5. Appearance of the alimentary canal under two-thirds of inch power.
Fig. 6. Ditto, under one-fifth.

PLATE XX.

Fig. 1. Posterior portion of *Gammarus*, showing the urinary—
a. Organs in position.
b. Sphincter muscles at termination of urinary organ.
c. Sphincter muscles at termination of alimentary tube.
Fig. 2. Urinary organs from *Sulcator arenarius*.
Fig. 3. Urinary organs from *Gammarus grossimanus*.
Fig. 4. Urinary organs from larva of *Amphitoë rubricata*.
Figs. 5 & 6. Ultimate structure of the organ.

PLATE XXI.

MALE.

Fig. 1. Testes from *Sulcator arenarius*, with their vas deferens and penis attached.
Fig. 2. Part of 7th segment, with coxa and penis attached.
Fig. 3. The under arch of 7th segment of pereion (thorax), with branchial vessels and penis attached, from *Gammarus*.
Fig. 3*a*. Extremity of penis.
Fig. 2*a*. Extremity of penis of *Sulcator*.
Fig. 4. Penis of *Caprella*.
Fig. 5. Spermatozoa of *Gammarus*.
Fig. 6. Spermatozoa of *Sulcator*.

FEMALE.

Fig. 7. Ovaries of *Gammarus*.
Fig. 10. Ovaries of *Caprella* (after Goodsir).
Fig. 8. Vulvæ of *Caprella*.
Fig. 11. Plate from incubatory pouch of *Caprella*.

PLATE XXII.

Fig. 1. Nervous cord of *Talitrus locusta*.
O. The calcareous arch under which it dips to the infra-œsophageal ganglion.
A. The cephalic or supra-œsophageal ganglion.
B. The infra-œsophageal ganglion hid by (O).
E. And following, one to each segment of the body.
Fig. 2. Lateral view of the internal arrangement of the head, showing the line which the nervous cord takes: letters the same.
Fig. 3. Diagram showing the circulation of the blood.

On the present state of our knowledge on the Supply of Water to Towns. *By* JOHN FREDERIC BATEMAN, *C.E., F.G.S.*

AMONG the many interesting and important subjects to which the present desire for sanitary improvement has recently directed public attention, none have a higher claim upon that attention, nor are more intimately mixed up with the health, the comfort and the well-being of our town populations, than the questions of an abundant supply of good and wholesome water, the complete and proper drainage of our houses and our cities, and the purification of the streams and rivers into which the sewage of our towns is allowed to flow. Scientific research, and the experience of daily life, are constantly bringing to view the close connexion which these questions have with the mortality, the comfort and the moral habits of our rapidly-increasing population.

The tendency to herd together in large cities for purposes of convenience and employment, the rapidity with which many manufacturing towns have

sprung into existence or increased in size,—outstripping all preparation or arrangement for the physical comfort and well-being of their inhabitants,—the deterioration of the dwellings of many of the older towns and the closer packing of the labouring classes for want of proper house accommodation, have all contributed to enhance the evils attendant upon a deficient supply of water and imperfect drainage.

The spread of manufactures and the valuable commercial purposes to which the waters of the country have been applied, have led to the deterioration of most of the streams to which the inhabitants formerly resorted for the supply of their domestic wants, and suitable natural supplies of water have now become either wholly deficient or lamentably inadequate to meet the demands of health and comfort. Systems of artificial supply have to be adopted, and in many cases these are attended with so much difficulty and expense, that every effort to inculcate right principles of supply, and to afford accurate information for the government of those engaged in carrying out works of so much value to the community, is entitled to attention and respect.

I have had the honour of being requested to prepare a Report on the present state of our knowledge on this subject, but the question is one which in its ramifications embraces so many points, that I shall not attempt, on the present occasion, to do more than draw attention to the different modes of supply which have been successfully adopted, and to give, as far as I am able, such examples or such information as may serve to illustrate general principles, without attempting to enter minutely into mechanical or practical details.

The supply of water to towns on a large scale appears to have attracted very little attention in Great Britain till a comparatively recent period. The general hilly nature of the country, its geological character, and the abundant and tolerably uniform fall of rain, have contributed to an almost universal diffusion of springs or streams, which, so long as they remained pure, supplied all the wants of the inhabitants, then thinly and widely spread, or gathered together into towns of only very moderate dimensions.

But as population has increased and manufactures have extended, as towns have become larger, and streams originally pure have become foul, the subject has of necessity forced itself upon the notice of the public and excited the attention it deserves. Works are now contemplated and carried into effect which rival the greatest undertakings of the ancients and the Romans, and not in this country only, but in America and on the continent of Europe the water-works of modern times are amongst the largest, the boldest and the most successful productions of the age. Cities and towns are now almost universally supplied with an unlimited quantity of water, conducted into the interior of the houses, supplying in the most perfect and convenient manner every domestic want. Protection against fire is secured by arrangements specially adapted for that purpose, by which in many places the simple pressure of the water is made to perform, and with much greater effect, the duty formerly supplied by the mechanical agency of the fire-engine. Streets are watered, and sewers are cleansed with little or no additional expense, and the general sanitary condition of our thickly-peopled districts is materially improved.

The general mode in which towns in this country were formerly supplied with water by artificial means still exists in some places, and is common in continental towns. It appears to be the same also which, to a great extent, was adopted by the ancients, and carried out on the grandest scale by the Romans in the height of their prosperity. It consists in collecting springs at

suitable heights and distances, and conveying the water by covered aqueducts or pipes to public wells or fountains in convenient situations, from which the inhabitants fetch water as they require it.

The supply to Rome on this system, is said to have amounted at one time to 50,000,000 cubic feet of water per day, for 1,000,000 of inhabitants, which is upwards of 300 gallons a-day to each person. Some of the water was brought a distance of nearly fifty miles, the works for its conveyance being of the most massive and expensive character. It was largely consumed in public and private baths, in fish-ponds and ornamental waters, as well as in supplying ordinary domestic wants. The abundance of the supply encouraged the universal habit of bathing, and contributed in many ways to the luxurious indulgence of the inhabitants. "If any person," says Pliny, in writing on the aqueducts for supplying Rome, "shall very attentively consider the abundance of water conveyed to the public, for baths, fish-ponds, private houses, fountains, gardens, villas—conducted over arches of considerable extent, through mountains, perforated for the purpose, and even valleys filled up,—he will be disposed to acknowledge that nothing was ever more wonderful in the world." With the fall of the Roman empire, however, the disposition or the means for carrying out works on this scale disappeared, and since then nothing for many centuries appears to have been done, even by the most enterprising cities, beyond that which was absolutely required for pressing and immediate wants.

The supply of water to London, which till lately has been far in advance of other places, is strongly illustrative of this. As local supplies became exhausted, springs were from time to time brought into the city, as its population increased and its wants required, and these supplied public wells or fountains, from which the inhabitants fetched the water in vessels as they required it. But it was a constant struggle to maintain a sufficient supply even for this limited use, and no means of artificially forcing water from low levels or conducting it into the interior of the houses was thought of, nor indeed was any large scheme attempted, until the year 1581, when Peter Morice, a Dutchman, proposed to raise water from the river Thames by means of pumps worked by a water-wheel, to be driven by the force of the current of the river and receding tide through one of the arches of the old London Bridge. This ingenious project was carried into effect in the following year, 1582, and was attended with so much success and advantage to the city, that several other arches of the bridge were appropriated to the same purpose. From an account of the works, written by Mr. Beighton, an engineer, and published in the Philosophical Transactions for 1731, there were at that time three water-wheels employed, which, if they worked constantly, would raise about 2,500,000 gallons of water in twenty-four hours. Allowing for the difference of the flow and ebb of the tide, probably nearly two-thirds of this quantity would be raised. These works continued, with some additions and improvements, till the removal of the old London Bridge, about the year 1822, being a period of 240 years from their first establishment. In 1821 there were six water-wheels employed, and the average daily quantity of water supplied was estimated at nearly 4,000,000 gallons.

This was probably the earliest *pumping* establishment on a large scale; but in the beginning of the seventeenth century a much more important scheme, on a different principle, that of *gravitation*, was proposed, and was, after years of difficulty, great self-denial, and the most praiseworthy perseverance, successfully completed by Sir Hugh Myddelton.

This proposal was, to convey pure water from the springs of Chadwell and Amwell in Hertfordshire, to the city of London, a distance along the line of

the aqueduct of about forty miles. For this object the Corporation of London obtained Parliamentary powers in 1606, and, after some delay, transferred their powers to Sir Hugh, then Mr. Hugh Myddelton, in 1609. In the year 1613 the original works were completed, and the water introduced into a reservoir for the supply of the city, at an elevation of about 84 feet above high water in the Thames; from which time the New River Works, as they were then, and have since been called, have largely contributed to the benefit of the city by supplying a large portion of its inhabitants with an abundant quantity of water for all their domestic wants. The original cost of the works is estimated to have been between £200,000 and £300,000; but the quantity of water which was first introduced I have not been able to ascertain. It soon, however, proved insufficient, and recourse was had to the river Lea. Additions to the supply have since been made in various ways from various sources, and at different times, until the supply afforded by the New River Water Company now amounts to about 18,000,000 gallons per day, which is delivered to about 500,000 persons.

It is not my intention to follow the history of the London water-works. I have thus briefly drawn attention to the first pumping and first gravitation schemes of magnitude in this country, for the purpose of marking the period of the earliest important undertakings, and of exhibiting the progressive development of works of this nature.

The invention of the steam-engine, and its application to the water supply of towns, towards the close of the last century, and the substitution of iron pipes for wooden ones, which does not appear to have taken place till about the year 1810, led to great extension in the quantity of water supplied, and to many improvements in the mode of conducting it through the streets, and introducing it into the houses of the consumers.

London is now supplied with water by nine different Water Companies, who jointly deliver about 44,000,000 gallons of water per day, and derive a revenue of about £236,000 a year. The water is principally derived from the river Thames or the river Lea, or brought in by the New River Company, and, according to the evidence given before the Committee on the Metropolis Water Bill in 1851, the steam-engines employed in raising or forcing water amounted at that time to a combined power of 3372 horses.

The different sources from whence a town can derive a supply of water, beyond that which the inhabitants can collect in cisterns from rain, or procure by wells on their own premises, may be classed as follows:—

1. From springs.
2. From Artesian wells, or from the water to be obtained from absorbent geological strata.
3. From rivers.
4. From gathering grounds, where the surplus water of wet seasons is collected into large storeage reservoirs. And
5. From natural lakes.

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1. *From springs.*—Where spring-water can be procured in sufficient quantity and of a quality suitable for domestic requirements, nothing can exceed, nor perhaps equal, this source of supply. Bright and sparkling, free from all vegetable contamination, and deliciously cool, the very idea of spring-water is refreshing to the senses; but it seldom happens that it can be procured conveniently in considerable volume, nor is it always the most suitable for domestic use. The water, from its solvent action on the rocks with which it comes in contact in passing through different geological strata, frequently undergoes material change between the time of its first resting on

the surface of the earth in the form of rain, and that of its final issue in the form of springs. The quality of spring-water, and indeed of that which flows only over the surface, varies constantly according to the geological character of the district on which it falls, or through which it passes. Thus most of the primitive rocks and many of the secondary ones, being composed of comparatively insoluble ingredients, impart little or no change to the water; while others, such as the old and new red sandstones, limestone, chalk, the rocks of the lias and oolitic formations and clays generally, are more or less acted upon by the water, imparting to it in various degrees a portion of their mineral or chemical constituents. Hence spring-water varies considerably in its character; and though, when not impregnated by mineral substances, it is generally agreeable and wholesome as a beverage, it is frequently unfitted for culinary and domestic uses, as well as for delicate purposes of trade, by reason of its chemical ingredients and its excessive hardness.

Dr. Clark of Aberdeen has invented a convenient mode of determining the relative hardness of water by the application of a soap-test. By his rule, "each degree of hardness indicates as much hardness as would be produced by one grain of chalk per gallon, held in solution in the form of bicarbonate of lime free from any excess of carbonic acid. . . . . A quantity of a soluble magnesian salt, equivalent to one grain of chalk, destroys a like quantity of soap-test, and consequently indicates one degree of hardness. The same is the case with the salts of iron and salts of alumina; salts of alkalies do not produce hardness." By this test it requires about 4° of hardness, according to Dr. Clark's scale, to break or curdle soap. By the use of this test it is shown that distilled water being zero, or possessing no hardness at all, rain-water, as freshly caught in towns, is generally from 1° to 2° of hardness. The springs which issue from such primitive rocks as granite or gneiss, from the mica-slate and clay-slate formations, from the millstone grit and from the greensands, as they are developed in Surrey, vary, with some exceptions, from about 1° to 3° of hardness; all these formations yielding water of the greatest natural purity. The springs of the new red sandstone vary generally from 5° to 20°, and the limestone- and chalk-waters from 10° to 20° of hardness, while those which issue from the lias and oolite run up to 30° and upwards.

I need not mention mineral springs and spa-water.

The chemical character of water has only recently been attended to, but in the selection of a water for the supply of a town, there is nothing more important than careful chemical investigation.

The instances of supplies of water being derived from springs, although the mode commonly adopted when towns were small and the demand for water limited, are now becoming rare; but it may be interesting to mention a few cases, and to give the particulars of some of the more important springs which have been appropriated or proposed to be applied for that purpose.

The city of Edinburgh was, till a recent period, supplied by springs collected in the Pentland Hills, and scrupulously guarded from all admixture with other water by the very able engineer of the Water Company, Mr. Jardine. The supply, however, proving insufficient, recourse has been had to the surface-water collected in large reservoirs, for which object very extensive works have just been completed by Mr. Leslie, the present engineer to the Company.

The whole district of the Staffordshire Potteries, comprising a very large population, is now supplied by a magnificent spring of very excellent water issuing from the new red sandstone in the valley of the River Churnet near Leek, which, after being raised by engine-power to the summit of a neighbouring height, is conducted several miles by iron pipes, supplying the district by

gravitation. Many smaller towns, particularly in the limestone, chalk, and oolite districts, also derive their supplies from springs, but the supplies thus afforded are in general comparatively insignificant to those obtained in other ways.

The quantity of spring-water yielded by any given district varies materially, not only according to the amount of rain which falls, but also according to its geological character. Sand, gravel, chalk, limestone and other absorbent rocks, yield springs in the greatest abundance; next to these, the more loosely stratified rocks, such as the coal-measures, the millstone grit, and the old red sandstone; least of all the closely-bedded slate rocks and the primitive formations.

Chalk and sand absorb nearly all the rain which falls upon the surface. There are few large rivers or streams in these formations, for little water runs away in floods, that which is absorbed escaping again at the points of greatest depression, or along the edges of some impervious stratum on which the measures may rest. Thus chalk springs are generally found at the foot of the chalk hills, either at the lowest level of the ground, or where the lower beds of this formation, above the greensand, are comparatively impermeable. The springs of the upper greensand issue along the upper edge of the gault, an impervious bed of clay on which it rests; and the springs of the lower greensand, where they again rest on the Wealden or Kimmeridge clays. The water absorbed by the lower oolite is thrown out by the lias clay, and the carboniferous limestone-water passes either through clefts or fissures in the rock to some convenient outlet; or having penetrated to the bottom of the limestone bed, is thrown out by the thick beds of shale which lie beneath.

The sands of the new red sandstone formation also absorb most of the water which falls upon them, as do also the local beds of sand and gravel found interspersed amongst the clays of the diluvium.

From all these sources, produced by absorbent measures, large quantities of spring-water may undoubtedly be procured, often continuing with little daily variation, and frequently so situated as to be easily available for the supply of towns. Many single springs yield several hundred thousand gallons a-day; some amount to upwards of 1,000,000, and there are a few which far exceed this quantity, forming at once rivers of considerable volume—such are the source of the Aire at Malham Cove in Yorkshire, the Syreford Spring and Seven Wells near Cheltenham, the Hogg's Mill River near Ewell in Surrey, the spring at Holywell in Wales, and many others.

But the most abundant quantity of spring-water yielded by any extended district is probably that which is found in the greensand formation in Surrey. Here this formation rises into hills of considerable elevation, Hindhead and Leith Hills being nearly 1000 feet above the level of the sea, forming arid wastes or sandy deserts almost destitute of vegetation, which are eminently absorbent of water. The water thus absorbed issues in springs of the greatest purity, forming collectively, in the dryest seasons, a volume of water at Guildford from a comparatively limited tract of country, exceeding 40,000,000 gallons of water a-day, 33,000,000 of which are the produce of the greensands, not exceeding on the average $2\frac{1}{2}°$ of hardness. One stream, the Potsford Brook, which rises in the Leith Hills and falls into the Albury Brook a little above Guildford, is under four miles in length, and yet gradually and almost imperceptibly increases to a daily volume, as measured in extreme drought, of nearly 5,000,000 gallons of pure spring-water. After running one mile, it contains 800,000 gallons a-day, in the second it is augmented to 1,400,000, and at the end of the third mile to 4,400,000. The gross quantity of soft spring-water which might be conveniently collected in this district at an elevation of about 120 feet above the Thames at

London, and conveyed thence, for a very moderate outlay, exceeds 40,000,000 gallons per day.

The sands of Delamere Forest in Cheshire yield a large quantity of beautiful water, not exceeding 5° of hardness, issuing along the margin of the closer measures on which they rest. From measurements made in the summer of 1851, the gross produce was 16,000,000 gallons a-day, from a tract of country not exceeding thirty-six square miles in extent.

The quantity of spring-water must of course depend much upon the amount of rain which falls upon the surface, even when the other conditions of the case are similar; but it is probable that in the two instances last named, there is little difference in the annual rain-fall. The Rev. Gilbert White, in his 'Natural History of Selborne,' gives the average rain at Selborne, close to the Surrey sand district, from thirteen years' observation (from 1780 to 1792), at 36·42 inches per annum; while at Liverpool, no great distance from Delamere Forest, the average annual rain is about 35 inches.

Passing from these absorbent measures, which are so eminently productive of springs, to those of older date and harder or closer texture, I am able to give, from extensive observation, some information upon the volume of spring-water produced by the sandstone district of the lower coal-measures and the millstone grit formation immediately beneath. These two groups of rocks usually produce spring-water of great excellence and softness, but owing to their general horizontal stratification, the frequent and great extent to which they are covered by drift clay and the numerous beds of impervious shale with which the sandstones and flag-rocks are interstratified; and also to the steep and hilly character of the surface which generally prevails where these formations are present, the bulk of the rain which falls runs off the ground in floods, and a comparatively small quantity finds its way through cracks and fissures into the interior of the earth, to be reproduced as springs.

Hence it is seldom that springs are found here in sufficient volume to supply large masses of population, and a different system of supply has been resorted to, that of storing the surplus water of wet seasons for use in periods of drought, which will form a separate subject of observation.

The volume of spring-water from equal areas varies considerably in the districts under consideration.

This is owing partly to elevation, partly to geological differences, but perhaps principally to the very variable quantity of rain which falls upon the surface. Taking the Penine chain of hills, which forms the boundary between the counties of York and Lancaster, and the various projecting spurs of the same range which run into both counties, as the most conspicuous development of these geological formations, the rain is found to vary 100 per cent. in the same year, although the district named is confined to very narrow limits. Thus the rain at Liverpool, Lancaster, and Manchester, on the plain beyond the western confines of the district, averages 35 inches per annum; at the foot of the hills, at Bolton and Rochdale for instance, it reaches nearly 50 inches; on the hills above Bolton, within the gathering grounds of the district supplying that town, Liverpool, Chorley, Blackburn and other places, the rain amounts to nearly 60 inches per annum. On Blackstone Edge, the summit of the ridge between Rochdale and Halifax, and in the Manchester Water-Works district, about half-way between Manchester and Sheffield, the annual rain is upwards of 50 inches. At the foot of the hills to the east, as at Sowerby Bridge and Halifax, it does not much exceed 30 inches; and further on to the east, as at Leeds and York, it falls to between 20 and 30 inches.

In like manner the spring-water varies in extreme drought from about $\frac{1}{4}$ of

a cubic foot per second for every 1000 acres of contributing area, as in the Washbourne, one of the tributaries of the river Wharfe in Yorkshire, to $\frac{3}{4}$ of a cubic foot per second from the same area, as in the river Etherow at the Manchester Water-Works. The spring-water of the Rivington Hills, from whence the supply of Liverpool is to be obtained, is equal in the same dry season to about half the quantity of that yielded by the Manchester district in proportion to their respective areas. The general lowest yield of these measures in the dryest weather, after a long period of drought, is about $\frac{1}{3}$ or $\frac{1}{2}$ of a cubic foot per 1000 acres. These are the quantities measured in the streams, the produce of considerable tracts of land, and are liable to be increased and discoloured by floods. There are seldom any large or important individual springs. The Manywells Spring, near Bradford in Yorkshire, is one of the largest. When at its lowest, except in extreme drought, it is about 200,000 gallons a-day, but will average about 500,000.

The abundance of spring-water found in the limestone which lies below the millstone grit has been alluded to. Of that which issues from the old red sandstone I have no certain information, but it probably closely resembles in quantity that yielded by the lower coal-measures and the millstone grit.

Beneath these, in geological series, the rocks generally become so compact and so little fissured as to allow the infiltration of a very small portion of the water which falls upon them, and the springs are consequently insignificant, notwithstanding the abundant quantity of rain which prevails in the mountainous districts peculiar to these formations. Measurements in the mica-slate in Scotland in the summer of 1853, give results smaller than those obtained in the millstone grit, notwithstanding the greater elevation of the ground and the much larger annual rain-fall.

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2. *From Artesian Wells.*—The obtaining of water by means of wells sunk into absorbent measures, "water-bearing strata" as they have been called, overlaid by other measures of a retentive or impervious character, or by wells sunk into permeable rocks like the new red sandstone, is a system which has been widely adopted, and with considerable success. Such is the mode by which both Paris and London are to a great extent supplied, as well as Liverpool, Birkenhead, Wolverhampton and other places in this country, and Tours, Calais, Venice and other places on the continent.

Where absorbent measures are covered by others of an impervious character, as the greensands and chalk are in the London basin by the plastic clay, and where the absorbent or water-bearing measures are supplied with the water they contain from elevated districts where they rise to the surface, and where they receive and absorb the rain, the manner in which the water is obtained is the most simple and convenient. A bore-hole of suitable size is sunk through the impervious overlying stratum or strata to the measures beneath, which are charged with water received from their distant elevated outcrops. As soon as the water-bearing measure is reached, the water pent down by the overlying impervious mass is released, and rises through the bore-hole to the surface of the ground, where, if the supply be abundant and the pressure great, it will overflow in a constant stream.

The name of Artesian Well is said to have been derived from wells of this description having been first constructed in Artois, in the north of France, where the geological structure of the country favoured their easy and economical construction. In France, large quantities of water are obtained in this manner. At and near Tours fifteen wells yield about 4,000,000 gallons per day; one well alone supplying as much as 950,000 gallons in twenty-four hours. The well at Grenelle, in Paris, yields 880,000 gallons of water

daily, and has continued, without diminution in quantity, since it was completed in 1841. The supply to the sand from which it rises is said to be derived 100 miles off; and yet such is the pressure, that it rises in a tube to the height of 120 feet above the surface of the ground at the well.

It is estimated that the quantity of water derived by means of Artesian wells by public and private parties within the city of London or its immediate neighbourhood, amounts to 8,000,000 or 10,000,000 gallons per day. This is obtained almost entirely from the lower tertiary sands and the upper beds of the chalk. Probably a much larger quantity could be procured from the greensands below the chalk. Mr. Prestwich, who has most ably entered into an examination of this question, is of opinion that 30,000,000 or 40,000,000 gallons of excellent water might be obtained daily in this manner for the supply of London.

The quality of the water will depend upon the character of the water-bearing stratum from which it is derived; the chalk will generally yield hard-water, the greensands generally soft. The water from the lower tertiary sands is occasionally chalybeate and unsuitable for domestic use. In nearly all cases, the water, after being first tapped, improves in quality as it continues to flow.

This source of supply is of course only available under certain geological conditions, and is always limited by the amount of water which the water-bearing stratum can absorb from rain or surface drainage, and by the resistance opposed to its free passage by the closeness of the material through which it has to pass.

Formerly the water in the Artesian wells which are sunk to the chalk in London, rose to the surface and overflowed; but the number of wells which have been constructed have in great measure exhausted the supply, and the water has now to be raised by artificial means from considerable depths.

The question of a supply of water by this means is one of great interest. It has been very carefully investigated by many able and competent men—by Mr. Prestwich, the Rev. Mr. Clutterbuck, Mr. Dickinson, Mr. Stephenson, Mr. Braithwaite, Mr. Homersham and others, to whose publications and to the discussions which have taken place in the Institution of Civil Engineers, useful reference may be made.

The water derived from wells in the new red sandstone forms a closely analogous system of supply.

Here the supply generally depends upon the porosity of the rock, the quantity of rain which falls upon its surface, the amount of infiltration, and the angle of friction which is formed by the resistance of the rock to the free passage of the water. The new red sandstone covers so large a portion of England that its capability for affording water is a question of corresponding interest. In some districts it is found to yield an abundant quantity, in others very little. It is generally hard, but well-aërated and agreeable to the taste.

The largest supplies from this source have been obtained in Liverpool, and owing to the long contest and repeated investigations as to the best means of affording an increased supply to that town, very ample information has been obtained as to the yield of the wells and the quality of the water. The Report of Mr. Robert Stephenson on this subject in March 1850, is full of valuable statistics. It appears that the supply then afforded by the new red sandstone from seven wells or stations, was 3,900,000 gallons per day, being an average of about 570,000 gallons for each well; but Mr. Stephenson arrived at the opinion that an isolated well in the new red sandstone at Liverpool might be assumed as capable of yielding about 1,000,000 gallons of water

per day. After careful study of the facts with which he became acquainted, he came to the following conclusions:—

"That an abundance of water is stored up in the new red sandstone, and may be obtained by sinking shafts and driving tunnels about the level of low water.

"That the sandstone is generally very pervious, admitting of deep wells drawing their supplies from distances exceeding one mile.

"That the permeability of the sandstone is occasionally interfered with by faults or fissures filled with argillaceous matter, sometimes rendering them partially or wholly water-tight.

"That neither by sinking, tunnelling, or boring, can the yield of any well be very materially and permanently increased, except so far as the contributing area may be thereby enlarged.

"That the contributing area to any given well is limited by the amount of friction experienced by the movement of the water through the fissures and pores of the sandstone; and

"That there is little or no probability of obtaining permanently more than about 1,000,000 or 1,200,000 gallons a day, and this only when not interfered with by other deep wells."

The hardness of the Liverpool public well-water varied from 5° to 28°, but many of the private wells far exceeded this. They ranged from 23° to 352°, the highest being evidently affected by saline infiltration from the sea-water of the Mersey.

Assuming Mr. Stephenson's conclusions as to the probable yield of wells in the new red sandstone as correct, although they are beyond what is realized in practice, and that each well withdraws the water within a radius of one mile, one million gallons per day will equal a depth of about 8 inches of water per annum over the whole surface, which must be absorbed and conducted to the well. The rain at Liverpool is 35 or 36 inches per annum on the average. After allowing for the loss occasioned by evaporation, vegetation, and such absorption as does not subsequently reappear in springs, and which has been ascertained to be from 12 to 16 inches and upwards, there would remain to supply springs and flow off in floods about 20 inches per annum, of which 8 inches would appear to permeate the rock, and be available for the supply of deep wells.

Similar experience is derived from a deep well sunk into the new red sandstone by the late Manchester Water-Works Company, at their works at Gorton, about the year 1845. This well was expected to have yielded 2,000,000 gallons per day, and it is stated to have actually yielded at one time 1,500,000. In 1850 it was represented to Mr. Stephenson as yielding 1,200,000, and in 1852, previous to its use being discontinued, the regular yield from daily measurements was 750,000 gallons per day. Here the rain, as at Liverpool, is about 36 inches per annum; and assuming the same extent of collecting area, the water raised, at 750,000 gallons per day, is equal to a percolation of little more than 6 inches per annum. In the Midland Counties, however, where the rain is much less in quantity, and where also there may be some lithological difference in the permeability of the rock, the yield from such wells as have been sunk with a view of obtaining water supplies is much less. At Wolverhampton, where the rain is probably under 30 inches, the yield of two wells sunk by the Water Company is only equal to about 200,000 gallons per day each. Some special causes may have affected the supply at these wells, but no greater quantity could reasonably be expected if the data afforded by Liverpool be made the groundwork for calculation. The only rain observations in that district are those which have been made at Lord Wrottesley's Observatory at Wrottesley, but as the rain-gauges are

placed at considerable elevations above the ground, they probably indicate much less than the real quantity of water reaching the surface. By these observations the average annual rain is about 20 inches, but allowing for the probable error, and assuming it at 25 or 26 inches, from which an annual loss of 15 or 16 inches must be deducted, there will remain only about 10 inches to supply floods and percolation, just half the quantity which remains at Liverpool and Manchester. As at those places it appears that much more water runs off in floods than remains both for floods and percolation at Wolverhampton, and as undoubtedly a large portion of the water will also run off the ground in floods in that district, a very small quantity can remain to give a constant supply to deep wells.

In all cases the red sandstone water has to be pumped out of the rock by artificial means. Except where the rock is very porous, and where the downward tendency of the water is little interrupted by intervening beds of shale, and where only it is abundantly supplied by rain on the surface, no large, convenient, or cheap supplies of water can be expected. The hardness of the Manchester water at the Gorton well was about 20°, of the water at Wolverhampton about 18°.

Some small supplies have been obtained by bore-holes in the coal-measures, particularly where they are covered by the new red sandstone; but they are comparatively of small moment.

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3. *From rivers.*—It has been so easy and natural a course to resort to rivers for a supply of water to towns, as the springs or local supplies on which they originally depended have failed or become exhausted, that except in districts where the streams have been greatly polluted, recourse to contiguous or convenient rivers has been a common practice. Thus the Seine has contributed a large portion of the supply to Paris. The Thames and the Lea contribute the bulk of the water consumed in London. The Clyde affords the main supply to Glasgow. The Ouse supplies York; the Lee, Cork; the Trent, Nottingham; the Dee, Chester; the Tyne formerly supplied Newcastle, and the Wharfe has just been laid under contribution for the wants of Leeds.

In general, however, rivers are being abandoned where other sources are within reach, partly from the fouling of the streams by the drainage of towns and by mining and manufacturing operations, and partly on account of the frequent discoloration of the water by floods or vegetable decomposition, and the difficulty of purifying the water so discoloured even by the expensive and troublesome system of careful filtration. But where the rivers are pure and free from discoloration, and local circumstances favour the adoption of such a supply, it possesses many and great advantages. The requisite works are simple and capable of easy extension, and the supply generally is most abundant. Such are the cases of Inverness, Aberdeen, and Perth, all deriving their supplies from rivers of unexceptionable quality.

River-water also possesses to a great extent a power of self-purification, so that a moderate admixture of foul water in the upper part of a stream does not necessarily render the water unfit for the supply of a place lower down in its course. In the case of the river Wharfe, for example, from whence the town of Leeds is to be partially supplied with water, Dr. Hofmann was unable to detect the presence of any noxious ingredient at the point at which it was proposed to withdraw the water, although it received the drainage of several small towns and villages, and the refuse of several woollen-mills situated at no great distance higher up on the river. The case, however, of the deleterious character of the water of the Thames is notorious, and I need scarcely cite

the evidence of Dr. Hassall. The Severn at Gloucester contains palpable indications of the sewage of Cheltenham, Tewkesbury and Worcester, and the Clyde at Glasgow is no longer fit for domestic use. Except, indeed, in mountain districts of such physical and geological character that the water can neither be injured by agricultural or mining operations, nor by the refuse of towns and manufactures, few rivers can be depended upon for a supply of good and wholesome water.

I now pass on to the consideration of the supplies derived—

4. *From "gathering grounds," where the surplus-water of wet seasons is collected into large storeage reservoirs.*—From these sources probably the most important supplies are now derived, and many points of considerable interest enter into the consideration of this branch of the subject.

Very accurate information is required as to the fall of rain, the loss by evaporation and vegetable absorption, the quantity of water which issues in springs or flows off the surface of the ground, the duration of droughts and the largest quantity of water which passes off the ground in limited periods, together with the requisite capacity of reservoirs for storing such water according to the character of the district or the annual amount of rain. Nearly all the correct information which we possess on these points has been collected within the last thirty years, the bulk of it within little more than half that period. So little was formerly known on these questions, that so recently as 1799 the late Dr. Dalton wrote a paper which was read before the Manchester Literary and Philosophical Society, entitled "Experiments and Observations to determine whether the quantity of Rain and Dew is equal to the quantity of Water carried off by Rivers and raised by Evaporation, with an inquiry into the origin of Springs." In this paper he examines the question by the aid of such meagre information as then existed, and arrives at the conclusion, "that the rain and dew of this country are equivalent to the quantity of water carried off by evaporation and by the rivers." He then examines the various opinions which at that time existed upon the origin of springs, combating the supposition that they were derived from some hidden subterraneous source, concluding that they must be attributed solely to the rain, their variation depending upon the seasons, and upon the quantity of rain which falls.

At this time Dr. Dalton determined that the average precipitation of rain and dew throughout the kingdom was 36 inches, allowing 31 inches for rain and 5 inches for dew. The highest returns of rain before him were from Kendal and Keswick, both under 60 inches per annum. Observations since then, some of the most important conducted by Dr. Miller of Whitehaven, have proved that the rain in many parts of the country far exceeds this quantity. In the mountainous district of Westmoreland and Cumberland, Dr. Miller has ascertained that the rain amounts in one locality to nearly 200 inches per annum.

On the hills between Lancashire and Yorkshire it amounts occasionally to 80 inches in a year, the average being between 50 and 60; and from observations recently taken in the Highlands of Scotland, it exceeds, at the head of Loch Katrine and Loch Lomond, 100 inches per annum. Judging by analogy, and from such facts as have been ascertained, it is probable that both amongst the mountains of Scotland and those of Wales, the rain will be as great as Dr. Miller has ascertained it to be in the English lake district. Such quantities form a striking contrast to those registered on the eastern coast of the country, where the average will not probably exceed 20 inches per annum.

The next important point is to ascertain how much of the rain which falls

is lost to the rivers and springs by evaporation, or by being taken up by vegetation. The physical and geological features of the country will produce very varying results. The proportionate quantity of water which will flow from steep mountain sides, consisting of impervious rocks, will be very different from that which will pass away from a gently undulating country well clothed with vegetation.

The first accurate observer on a large scale in this department appears to have been the late ingenious Mr. Thom of Rothesay, the constructor of the Shaws Water-Works, near Greenock.

The following is the result of information which he gave some years ago to the Institution of Civil Engineers on the rain which fell in 1826 and in 1828, the former year being the dryest year on record, and the latter, one in which there fell more than the average amount of rain:—

	inches.
From the 1st April 1826 to 1st April 1827, the fall of rain in Bute was	45·4
Of which there found its way to the reservoirs	23·9
Lost to the reservoir	21·5

In 1828 the rain at Greenock Reservoir was 60 inches, of which there flowed to the reservoir 41 inches, showing a loss by evaporation, vegetation, absorption, &c., of 19 inches. Further observations by Mr. Thom led him to the conclusion, that the loss bore a certain definite proportion to the rainfall; and the late Mr. Stirrat of Paisley, also an accurate observer, viewed the question in the same light; their average results giving the loss at about $\frac{3}{10}$ths or $\frac{4}{10}$ths of the whole fall, when the annual amount was from 54 to 65 inches. This conclusion was no doubt correctly arrived at from the facts before them, but it is obvious from a little reflection that this mode of calculation is inapplicable to other districts, where a much larger or a much smaller quantity of rain might fall. For instance, the requirements of vegetation and the amount of evaporation are usually much less where a large quantity of rain falls, while at the same time the ground is generally less absorbent and the declivities greater, and it evidently follows that the loss by evaporation and vegetation must be less under such circumstances than in a rich level country, where the rain is not nearly so great. By assuming a certain definite proportion of the whole rain, the reverse would appear to be the case. Take, by way of illustration, 100 inches in a sterile mountainous country, the loss at $\frac{3}{10}$ths would be 30 inches; and take 30 inches again as the rain in a fertile level country, the loss at $\frac{3}{10}$ths would be but 9 inches, obviously inconsistent with the real facts of the case. The truth appears to be, that the loss within certain limits is a tolerably constant quantity, and that generally the greater the rain the less the deduction ought to be.

The observations of Mr. Thom and Mr. Stirrat alluded to, give the annual loss at from 18 to 23 inches per annum, out of rain-falls of 54 inches and 65 inches respectively. Measurements and observations in 1852 in the Gorbals Water-Works district, closely adjoining those in which these observations were made, and in which there is about the same amount of rain, show the loss to have been but 12 inches out of 60. The average loss from several years' observations at the Manchester Water-Works is about 12 inches per annum. Mr. Hawksley's observations at the Liverpool New Water-Works, in 1847, show a loss of $12\frac{1}{2}$ inches.

Other observations scattered over the country show the loss to be ordinarily from 12 to 16 inches, and to a great extent to be irrespective of the rain which falls. In determining, therefore, the probable quantity of water which may be collected from any district, other than one of an absorbent character, it is necessary first to ascertain the fall of rain, and then, having due regard to

the state of cultivation, to physical features and geological structure, to make such a deduction for the loss by evaporation and vegetation, as, in the absence of correct experiments, may under the circumstances appear to be just. But in estimating this quantity as a supply to towns, it is not safe to calculate upon an average of seasons. It is scarcely possible to provide storage which will equalize the extremes of wet seasons and dry ones. The average of two or three successive dry years should be taken as the standard.

The storage requisite for equalizing the supply afforded during this period should be provided with a due regard to the continuance of drought and the quantity of water which will flow off the ground in extreme wet seasons. No water should be allowed to run to waste. Experience has shown that in the regions of comparatively moderate rain in this country, the storage to effect this object should vary from 20,000 or 30,000 cubic feet to 50,000 or 60,000 cubic feet for each acre of collecting ground, the smaller quantity being about sufficient for an available annual rain-fall of perhaps 18 inches, and the larger for one of about 36 or 40 inches. Or in estimating the storage by time, it should be sufficient to afford the average daily supply of the district for 100 or 120 days where the available rain is 40 inches per annum or upwards, and where the rain is frequent and heavy; and for 200 or 250 days where the rain is less, and where the annual available quantity will not exceed 8 or 12 inches, due allowance in every case being made for the produce of the springs in protracted droughts.

The year 1852 was a remarkable year, not only in its meteorological features, but as affording valuable information for the guidance of the hydraulic engineer. In that year there occurred probably one of the longest droughts of which we have any correct record, and the heaviest falls of rain within short periods. The total annual fall was but an average, and reservoirs for a town's supply should have been able to collect nearly all the water which flowed off the ground during the periods of excessive wet, to have afforded a full daily supply throughout the whole duration of the drought. In the Manchester Water-Works, the rain was just an average, the average being about 50 inches per annum. Rather more than half the whole quantity fell in the two first and two last months of the year. The quantity of water which flowed from 18,900 acres between the 1st of January and the 9th of February exceeded 800,000,000 cubic feet. The rain in the same period, taking the average of what was indicated by the gauges, was 12 inches. The flow from the ground, accurately measured through reservoirs, equalled $12\frac{1}{3}$ inches, the rain-gauges evidently indicating less than the real fall. From the evening of the 4th of February to the morning of the 5th, the quantity of water received into the reservoirs was equal to a depth over the whole surface of the ground of $2\frac{4}{10}$ inches. This excessive rain was followed by a drought of 110 days in duration, occasional wet days having occurred during this period, which would reduce the net duration of the drought to 105 days. In the year 1850, at the Whittle Dean Water-Works, which supply Newcastle-upon-Tyne, the reservoirs went down constantly for 240 days, the whole available produce of the district being but $6\frac{1}{3}$ inches in the year, out of $17\frac{2}{3}$ inches of rain-fall. At Warrington, in the year 1854, there was no appreciable supply of water for 230 days, the reservoirs and the springs constantly decreasing during that period. The total produce of the year was but 8 inches out of 27 inches of rain-fall.

These are a few of the points which require to be considered in connexion with the system of obtaining water from "gathering grounds." The amount of information now existing in a scattered and unpublished form is very large, and if properly brought together, would form a valuable contribution

to our knowledge on this subject. Most large modern undertakings have been laid out on this principle, and the constantly accumulating information enables the engineer to revise his data, to correct errors, and to make his calculations with additional certainty. To enumerate the works on this principle would be to name most of the important water projects of modern date in this country and in America. The Croton Aqueduct, constructed between the years 1835 and 1842, for the supply of New York in America, from a source nearly forty miles distant, at a cost of £2,500,000, and which yields a daily supply of about 30,000,000 gallons a day, was one of the first large works on this system. The Cochituate Works, for the supply of Boston, United States, are of more recent date. They supply about 7,000,000 gallons per day to 140,000 persons. The distance is twenty miles, and the cost has been about £1,500,000. The Gorbals Water Works, as they are now completed, receive their supplies from a tract of elevated ground of 2750 acres in extent, furnishing the city of Glasgow and its neighbourhood south of the Clyde with about 4,000,000 gallons of good water per day, besides a stipulated compensation to the stream of 1,310,712 gallons. The annual rain is about 45 inches on the average, and the capacity of the reservoirs equal to 61,000 cubic feet for each acre of collecting ground.

The Liverpool Water-Works, now nearly completed, in the neighbourhood of the hills known by the name of Rivington Pike, near Chorley, will collect the water from about 10,000 acres of hilly ground, and are estimated to be capable of affording a supply of from 12,000,000 to 15,000,000 gallons of water per day, after giving about half that quantity as compensation to mills. The rain is about 57 inches on the average, and the capacity of the reservoirs about 49,000 cubic feet per acre of collecting ground.

The Manchester Water-Works, which are now all but completed, and which have supplied Manchester for nearly five years, collect the water from about 19,000 acres of mountain ground, and are calculated to afford, when finished, about 25,000,000 gallons per day to Manchester and its neighbourhood, besides giving 17,000,000 as compensation to the mills on the river upon which the works are constructed. The average rain is a little above 50 inches; the total storage upwards of 600,000,000 cubic feet, or about 34,000 cubic feet per acre. Much water runs to waste for want of sufficient storage.

The supplies to Sheffield, Newcastle-upon-Tyne, Halifax, Blackburn, Bolton, Bristol, Edinburgh, and most of the large towns and cities in the manufacturing districts, and in the north of England and Scotland, are supplied in the same manner; but it would be tedious and needless to describe the peculiarities at each place.

There is, however, one point in connexion with the supplies obtained in this way which should not be passed over. Water obtained from gathering grounds is occasionally, sometimes frequently, discoloured in times of heavy rain, and is rendered unfit for immediate supply to the inhabitants of a town. Various methods have been adopted for obviating this objection. In some cases the discoloration from peat or other causes is so great, that no means which can be practically adopted on a large scale have been sufficient to clarify or purify the water to such an extent as could be desired.

In many works a system of clarification has been adopted by means of a succession of reservoirs, in which the water is allowed time to deposit impurities, being gradually decanted off from one to another, until it at last becomes fitted for consumption. In others, mechanical filtration has been applied, the water being passed through layers of fine sand; but no mechanical filtration will effectually remove the stain of peat.

In most gathering grounds the water is at times perfectly pure, and a very large portion of that which flows off the ground is in the most unexceptionable condition for immediate consumption. If this were mixed with that which had been previously stored in a discoloured state, the whole might be spoiled, and deposition or filtration would have to be resorted to.

Taking advantage of these circumstances, a system of separation has been adopted in many works, and in the largest and most complete manner in those for the supply of Manchester. There, by simple self-acting means, not liable to any derangement, each stream subject to discoloration is made to separate itself, the pure uncoloured water either flowing direct to Manchester or to reservoirs set apart for the storage of pure water. The turbid water flows to other reservoirs, where it either bleaches and settles for subsequent use, or is employed in affording the required quantity of compensation water to the mills on the stream. This system is probably the simplest, cheapest, and most effective which has been suggested; and though only recently introduced, is becoming very general, where circumstances are favourable for its adoption.

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5. *The supply from natural lakes.*—This supply can scarcely be said to differ from that of gathering grounds and large storage reservoirs, but there are one or two peculiarities which it may be desirable to allude to.

Its simplicity, where it can be adopted, is a material recommendation. It saves the construction of large artificial reservoirs, which is sometimes one of the most difficult works that an engineer can undertake. The great depth, and frequently the large surface, of water which is exposed, in comparison with the collecting area, favour the clarification of the water, and, as lakes are generally found in mountainous districts and in the harder geological measures, the water is frequently of the very purest quality. The towns of Whitehaven and Dumfries are supplied with water from natural lakes; the first from Ennerdale Lake in Cumberland, and the latter from Loch Rutton in Dumfriesshire. The town of Inverness is also supplied from lake water, the water being taken from the river Ness, a few miles below Loch Ness. But the largest work of this kind when completed will be the supply to the city of Glasgow with water from Loch Katrine, a work for which parliamentary sanction has been obtained, and which is now being carried out. The distance is about thirty-four miles, and the supply to the city will be 50,000,000 gallons per day.

Objections have been taken to the quality of these mountain lake waters on account of their excessive purity and their violent action upon new lead under certain circumstances. Similar objections were urged to the supply of very soft and excellent water to the cities of New York, Philadelphia and Boston in the United States, but experience has shown that no practical evil has resulted, either in that country or in this, from the passage of such water through leaden service pipes in any *town's* supply of water.

The supply of water in the towns of Inverness and Whitehaven, both of which are supplied with water of the greatest softness and the utmost purity, almost equal in all respects to distilled water, are striking instances of the safety with which such water can be conveyed to the inhabitants through leaden pipes and cisterns. Inverness has been supplied with Loch Ness water for upwards of five-and-twenty years, through the intervention of lead pipes and cisterns, without a single case of illness ever having occurred which could be attributed in the slightest degree to the contamination of the water by lead.

In Whitehaven the water was introduced from Ennerdale Lake in the summer of 1850. This water is of the same degree of purity and softness as

the Loch Ness water. The average mortality of the town for the four years preceding the introduction of the lake water was 34·8 per 1000, and for the four years subsequently the average deaths were only 23·5 per 1000. Except the new supply of water, there was no apparent cause for this amelioration. These cases clearly demonstrate the great benefit which results from the supply of eminently pure water, even though it should be delivered to the inhabitants through leaden pipes and cisterns. Any objection, however, on this score does not apply to the water, but to the means of its distribution, and the evil, if any, can be obviated in various ways.

There are still many points of much interest connected with the supply of water, and the sources from which it should be obtained, apart from all engineering and mechanical details, which have not as yet been touched upon; but their investigation would occupy considerable time, and they must be reserved for future consideration.

Fifteenth Report of a Committee, consisting of Professor DAUBENY, Professor HENSLOW, *and* Professor LINDLEY, *appointed to continue their Experiments on the Growth and Vitality of Seeds.*

THESE experiments have been continued under circumstances similar to those of preceding years, and the results are registered in the annexed Table.

Name and Date when gathered.	No. sown.	No. of Seeds of each Species which vegetated at			Time of vegetating in days at			Remarks.
1842.		Oxford.	Cambridge.	Chiswick.	Oxford.	Cambridge.	Chiswick.	
1. Aconitum Napellus	100							
2. Adonis autumnalis	50							
3. Amaranthus caudatus	100							
4. Anagallis arvensis	100							
5. Buffonia annua..................	100							
6. Buphthalmum cordifolium ...	100							
7. Bupleurum rotundifolium ...	100							
8. Conium maculatum	100							
9. Cytisus Laburnum	50							
10. Dipsacus laciniatus	50							
11. Elsholtzia cristata	100							
12. Erysimum Peroffskianum ...	150							
13. Helianthus indicus	25							
14. Heracleum elegans	50							
15. Hyoscyamus niger	100							
16. Iberis umbellata	100							
17. Iris sibirica	50							
18. Lathyrus heterophyllus	50	1	....	......	25–30	....	......	Healthy.
19. Leonurus Cardiaca	100							
20. Malcomia maritima	100							
21. Momordica Elaterium	25	......	....	4	...	....	30	Strong.
22. Nepeta Cataria..................	100							
23. Nicandra physaloides	100	28	48	22	25–30	8	16–24	
24. Nigella nana......................	50							
25. Orobus niger	50							
26. Potentilla nepalensis	50							
27. Stenactis speciosa	100							
28. Tetragonolobus purpureus ...	25							
29. Trigonella Fœnum-græcum...	50							
30. Tropæolum majus	25							
31. Cucurbita Pepo, var.	15							

Name and Date when gathered. 1842.	No. sown.	No. of Seeds of each Species which vegetated at			Time of vegetating in days at			Remarks.
		Oxford.	Cambridge.	Chiswick.	Oxford.	Cambridge.	Chiswick.	
32. Gilia achilleæfolia	100							
33. Capsicum, sp.	25							
34. Calandrinia speciosa	100							
35. Callichroa platyglossa	100							
36. Collomia coccinea	100							
37. Coreopsis atrosanguinea	100							
38. Cotoneaster rotundifolia	20							
39. Cratægus macrantha	50							
40. Cynoglossum glochidatum	100	......	....	3	......	....	20	Strong.
41. Digitalis lutea	100							
42. Eutoca viscida	100							
43. Glaucium rubrum	100							
44. Godetia Lindleyana	100							
45. Gladiolus psittacinus	100							
46. Impatiens glanduligera	50							
47. Lupinus succulentus	100							
48. Malope grandiflora	100							
49. Nolana atriplicifolia	100							
50. Oxyura chrysanthemoides	100							
51. Papaver amœnum	100							
52. Phacelia tanacetifolia	100							
53. Sphenogyne speciosa	100							
54. Acacia, sp.	100							
55. Betula alba	200							
56. Carpinus Betula	100							
57. Catalpa cordifolia	50							
58. Cercis canadensis	50							
59. Cerinthe major	50							
60. Cichorium Endivia, var.	150							
61. Cobæa scandens	6							
62. Cuphea procumbens	50							
63. Dolichos lignosus	25	13	53	7	20–25	10	15–20	Strong.
64. Galinsogea trilobata	100							
65. Ilex Aquifolia	100							
66. Juniperus communis	100							
67. Liriodendron Tulipiferum	50							
68. Loasa nitida	100							
69. Magnolia, sp.	15							
70. Martynia proboscidea	20							
71. Medicago maculata	100	17	66	18	20–25	1–21	18–30	
72. Mesembryanthemum crystallinum	100							
73. Mirabilis Jalapa	25							
74. Morus nigra	100							
75. Ricinus communis	15							
76. Scorpiurus sulcatus	25							
77. Tetragonia expansa	15							
78. Ulex europæa	100	11	55	......	25–30	6		

Report on Observations of Luminous Meteors, 1854–55. *By the* Rev. BADEN POWELL, *M.A., F.R.S. &c., Savilian Professor of Geometry in the University of Oxford.*

THE present Report presents, I fear, but a meagre appearance in comparison with some of its predecessors. But among the meteors recorded will be found some of considerable interest. I have to express my obligations to the several friends who have contributed their observations, chiefly the same who have favoured me on former occasions.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1854. Oct. 3	h m s 6 45 p.m.	Commenced as a bright point; increased and burst.	Middle of the stream bright white, each edge deep blue.	Burst in a long stream of light obliquely towards N.	About 6 or 7 secs.
14	9 0 p.m.	Like a rocket	Brilliant	Long luminous train	5 or 6 secs. ....
22	7 45 (G.M.T.)	A large fire-ball about ¼ moon's diameter.	Intensely bright, clear and vivid white, dazzling.	Leaving scintillations or sparks of a whitish red colour on all sides.	Rapid; described a path of about 30° and exploded.
Dec. 10	9 44	Large meteor	White	No train or sparks	Slow................
14	10 5	Large meteor	Whitish	Sparks	Slow................
1855. April 18	8 58 (G.M.T.)	Very bright meteor, = Venus, and as well defined.	Steady light...	No train	3 or 4 secs., moved slowly and steadily; disappeared instantaneously.
Aug. 12	10 14	Large meteor	Reddish	Long and brilliant train of sparks.	Slow................

Luminous Meteors observed 1854–55,

1854. Oct. 7	8 45 p.m.	¼ size moon...........	Yellowish......	Long tail	Rapid ....
Dec. 9	11 20 p.m.	2nd mag.*	Orange-red ...	Streak left	Rapid ....
10	8 5 p.m.	2nd mag.*	Blue............	Streak	Rapid ....
12	1 6 a.m.	2nd mag.*	Red	Streak	Rapid ....
1855. Jan. 13	11 44 p.m.	1st mag.*...............	Colourless ...	Long streak	1½ sec. ....
17	6 50 p.m.	1st mag.*...............	Yellow	Streak left	1 sec. ....
	6 50 30 p.m.	2nd mag.*	Yellow	Streak	0·½ sec.............
April 17	9 32 p.m.	5th mag.*	Colourless ...	No tail	0·1 sec.............
May 4	11 48 p.m.	1st mag.*...............	Yellow	Tail	Rapid ....

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
by N., alt. about 25° under Bootes.	Light, rather hazy. Moon half-full.	Driffield, near Beverley, Yorkshire.	Rev. D. Blanchard.	MS. communicated by Rev. T. Rankin.
m N.E. to S.W. over the enith.	Became much brighter before disappearing.	Banktop Station, L. & N.W. Railway, Manchester.	H. Fletcher, Curator of Lit. and Philos. Society. Another account in the *Manchester Examiner*, Oct. 21, 1854.	MS. communicated to Mr. Greg.
N.N.W. towards W. below Lyræ.	....	Langley, near Hitchin, Herts.	Mr. G. F. Ansell, Chemist to the Royal Panopticon, London.	MS. communicated to Mr. Birt. See App. No. I.
ow α Aurigæ to Ursa Major.	Brilliant	St. Ives, Hunts.	J. King Watts.	MS. communicated to Prof. Powell.
m α Persei towards the outh.	Very brilliant	Ibid................	Id.	Ibid.
alt. 5°	Venus visible	Washington Chemical Works, Fence houses (Durham).	Mr. John Watson.	MS. communicated to Prof. Powell. See App. No. II.
n Polaris to S.W.	A very beautiful and brilliant object.	St. Ives, Hunts.	J. King Watts.	MS. communicated to Prof. Powell.

by E. J. Lowe, Esq., F.R.A.S.

35° N.W. by W., moved ° towards N.	....	Nottingham......	F. E. Swann, Esq., & Capt. A. S. H. Lowe.	E. J. Lowe's MS.
at angle 45° towards W., ssing through δ Andromedæ.	....	Observatory, Beeston.	E. J. Lowe	Ibid.
ing down through Rigel ...	....	Ibid................	Id.	Ibid.
n at angle 45° towards S., ssing 2° S. of Sirius.	....	Ibid................	Id.	Ibid.
endicular down, passing 2° . of Polaris, moved 30°.	....	Ibid................	Id.	Ibid.
ly from ψ to ο Aquarii, ineased from a mere point.	....	Ibid................	Id.	Ibid.
ı ζ to ϑ Pegasi...............	....	Ibid................	Id.	Ibid.
n, inclining W., passed beeen β and δ Leonis.	....	Ibid................	Id.	Ibid.
ı ζ Bootis towards ι Virnis.	....	Ibid................	Id.	Ibid.

355.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1855. July 13	h m s 11 14 30 p.m.	Twice size ♃, and 4 times as bright as ♃.	Intense blue...	Disappeared suddenly when at its maximum brightness.	Very slow, last 2 secs.
14	12 0 a.m.	=2nd mag.*	Blue............	Tail	Very rapid, $\frac{1}{5}$th a second.
28	12 53 a.m.	=2nd mag.*, and as bright as 1st mag.*	Bluish	Short tail.....................	Almost instantaneous.
Aug. 1	1 0 a.m.	2nd mag.*	Colourless ...	Streak	Instantaneous ..
3	10 0 p.m.	As large as ♃, but only as bright as 5th or 6th mag.*	Colourless ...	Trail of light left	2 secs. ....
	10 12 p.m.	=2nd mag.* in size, and as bright as ♃.	Blue............	Resembled a reflected flash of lightning.	Instantaneous ..
	10 15 p.m.	5 or 6 times the size of Jupiter.	Bluish	Long streak left behind ...	Left a train of l[illegible] behind 25° length, dura[illegible] 1 sec.
	10 25 p.m.	=2nd mag.*	Blue............	Leaving a streak	....
	10 52 p.m.	=$\frac{1}{4}$ size moon.........	Colourless, and then blue.	Streak	....
4	1 14 a.m.	=2nd mag.*	Colourless ...	Streak	....

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
·om ɩ Serpentis through δ Ophiuchi, fading away near ζ Ophiuchi, having a single ray in front.	.... 	Observatory, Beeston.	E. J. Lowe	E. J. Lowe's MS.
ırough Polaris from the direction of β Cygni.	....	Ibid..............	Id.	Ibid.
·om 1° below α Andromedæ down towards S. at an angle of 50°, moved over 30° of space.	....	Ibid..............	Id.	Ibid.
om γ Ursæ Minoris through Draco to near ζ Ursæ Majoris.	....	Ibid..............	Id.	Ibid.
om β Herculis through α Coronæ Borealis. Very singular. I could evidently see the body (which was oval in form), and apparently not ¼ mile in the air. The stars were shining brightly.	.... 	Ibid..............	Id.	Ibid.
›peared at ε Aquilæ, and only moved over 0° 15′ of space.	....	Ibid..............	Id.	Ibid.
om the direction of β Pegasi, starting from a point 5° above ε Pegasi, passed through ε Pegasi, and faded near μ Aquarii.  It instantly increased from a point to its maximum size and brightness, and after travelling for 1 sec. as instantaneously disappeared. It cast a light upon the ground.	....	Ibid..............	Id.	Ibid.
›m β Cygni towards Cassiopeia.	....	Ibid..............	Id.	Ibid.
st visible in S.S.W. at an ıltitude of 45°, it moved down ın a curve to W.N.W. bursting at an altitude of 25°, considerably brighter than the moon, being as light as day. For more than half its course t was a colourless, well-defined circular body, leaving a streak of light behind in its track. When more than half-way, the meteor altered, increasing to double its original size, became blue in colour, and the edges ill-defined. Disappeared suddenly, having been visible 2 secs.	....  When first seen. Afterwards.	Ibid..............	Id.	Ibid.
rizontally from ½° above Vega, moving from S.E. to N.W.	....	Ibid..............	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1855. Aug. 4	h m s 1 15 a.m.	=2nd mag.*	Colourless ...	Streak	....
	1 17 a.m.	=2nd mag.*	Colourless ...	Streak	....
	1 17 30...	=2nd mag.*	Colourless ...	Streak	....
	11 1 p.m.	=2nd mag.*	Colourless ...	Streak	....
5	12 59 a.m.	=2nd mag.*	Colourless ...	Streak	....
	11 47 p.m.	=2nd mag.*	Blue	Streak	Instantaneous ..
8	12 57 a.m.	=1stmag.*&brighter than 1st mag.*	Blue	Long streak of light left behind.	Very rapid, du tion 0·2 sec.
	1 1 a.m.	=2nd mag.*	Blue	Streak	Instantaneous ..
9	10 3 p.m.	=1st mag.*............	Blue	Streak	Rapid ....
	10 0	=1st mag.*............	Blue	Streak	Rapid ....
	10 0 30...	=1st mag,*............	Blue	Streak	Rapid ....
	10 9	=2nd mag.*	Colourless ...	Streak	Rapid, duration sec.
	10 10	Twice size of 1st= mag. star.	Blue	Long streak..................	Rapid, duratio sec.
	10 11	=♃, and similar in every respect, and in the same path as the last meteor.			
	10 15	Small meteor in Pegasus.		....	....
	10 16	Another small meteor in Pegasus.		....	....
	10 19	=2nd mag.*	Colourless ...	Streak	Rapid ....
	10 18 30...	Small	....	Streak=3rd mag.*	....
	10 21	=2nd mag *	Blue............	Streak	....
	10 24	=3rd mag.*	Colourless ...	Streak	....
	10 26	=2nd mag.*	Blue............	Train	Rapid ....
	Between 10^h 24^m and 10^h 26^m six other small meteors.				
	10 28	=1st mag*............	....	With train of light	Rapid ....
	10 27	Small	....	....	....
	10 27 15...	=2nd mag.*	Blue	....	Stationary ..
	10 31	=2nd mag.*	....	Tail, which lingered	....
	10 32	=2nd mag.*	Blue............	....	....

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
'erpendicularly down from 1° S. of Vega.		Observatory, Beeston.	E. J. Lowe	Mr. Lowe's MS.
erpendicularly down from 1° S. of Delphinus.		Ibid.	Id.	Ibid.
erpendicularly down from β Bootis.		Ibid.	Id.	Ibid.
rom β Cygni towards Cassiopeia.		Ibid.	Id.	Ibid.
loved towards Vega from α Cephei.		Ibid.	Id.	Ibid.
assed down through β Persei, coming from the direction of Cassiopeia.		Ibid.	Id.	Ibid.
om 1° W. of γ Ursæ Minoris to ι Draconis.		Ibid.	Id.	Ibid.
om 1° below β Andromedæ through the head of Perseus to χ Piscium.		Ibid.	Id.	Ibid.
ll down from β Urs. Min. ...		Ibid.	Id.	Ibid.
These two fell down from between β and γ Urs. Maj. inclining to W.		Ibid.	Id.	Ibid.
oved upward from 1° above χ Cassiopeiæ.		Ibid.	Id.	Ibid.
om 1° above β Cassiopeiæ, passing through Vega. It left behind a streak of light 20° long, all of which faded away except 1° in length of that portion about 5° N. of where the meteor vanished. This portion was visible 1 min. and gradually became narrower.		Ibid.	Id.	Ibid.
arting at β Cassiopeiæ, and moving towards α Cygni.		Ibid.	Id.	Ibid.
		Ibid.	Id.	Ibid.
		Ibid.	Id.	Ibid.
om β to α Andromedæ		Ibid.	Id.	Ibid.
ll downwards from near λ Draconis.		Ibid.	Id.	Ibid.
om γ Pegasi nearly horizontally towards ϑ Piscium.		Ibid.	Id.	Ibid.
om μ Aquarii through τ Capricorni.		Ibid.	Id.	Ibid.
om Polaris horizontally to 1° N. of β Cassiopeiæ.		Ibid.	Id.	Ibid.
om midway between χ Cassiopeiæ and η Persei, moving towards the S. and passing between γ and τ Andromedæ.		Ibid.	Id.	Ibid.
nebula of Andromeda		Ibid.	Id.	Ibid.
out 4° N. of the cluster in the Sword-handle of Perseus.		Ibid.	Id.	Ibid.
ssed between α Andromedæ and β Pegasi.		Ibid.	Id.	Ibid.
om 1° N. of the Sword-handle of Perseus, perpendicularly down. Two other small ones, positions not marked.		Ibid.	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1855.	h m s				
Aug. 9	10 33	=4th mag.*	....	Streak	....
	10 35	=3rd mag.*	....	Streak	....
	10 36	Small	....	Streak	....
	10 37	=3rd mag.*	....	Streak	....
	10 40	=3rd mag.*	Colourless ...	Streak	....
	10 41	=2nd mag.*	....	Streak	Rapid ....
	10 42	=3rd mag.*	....	....	....
	10 42 30...	=4th mag.*	....	Streak	....
	10 43	=4th mag.*	Colourless ...	Streak	Rapid ....
	10 52	=2nd mag.*	Bluish	Having a streak which lingered 10 secs. after the meteor had disappeared.	....
	10 52 15...	=3rd mag.*	....	Streak	Rapid ....
	10 54	=3rd mag.*	....	Streak	Rapid ....
	10 55	=4th mag.*	Blue	Streak	....
	10 56	=2nd mag.*	....	Leaving a long blue streak behind.	....
	11 0	=2nd mag.*	Bluish	Leaving a long streak......	....
	11 5	Small	....	....	....
	11 7	Two meteors of the 3rd mag. were falling together.	....	Leaving streaks	....
	11 12	=3rd mag.*	....	With streak.................	....
	11 13	=2nd mag.*	Colourless ...	Streak	....
	11 16	=1st mag.*	Brilliant	Streak	....
	11 17	=3rd mag.*	....	Streak	....
	11 50	=5th mag.*	....	With streak.................	....
	11 56	=3rd mag.*	....	....	....
	11 57	=2nd mag.*	....	With a train of light	....
10	12 1 40...	=1st mag.*	Colourless ...	Long streak.................	Duration 1 se[c]

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
...rpendic. down from χ Cassiopeiæ.	....	Observatory, Beeston.	E. J. Lowe	Mr. Lowe's MS.
...om 2° S. of the Sword-handle of Perseus, moving nearly horizontally towards S. inclining in an angle of 5°.	....	Ibid.	Id.	Ibid.
...om ϱ Coronæ Borealis to γ Herculis.	....	Ibid.	Id.	Ibid.
...om Pegasus down towards E.	....	Ibid.	Id.	Ibid.
...om α Pegasi, nearly horizontal, slightly inclined downwards, moved 4° towards N.	....	Ibid.	Id.	Ibid.
...om between ι and ζ Ursæ Maj. towards W. nearly horizontal, passing under η Ursæ Maj.	....	Ibid.	Id.	Ibid.
...milar to the last, and in the same path.	....	Ibid.	Id.	Ibid.
...om Polaris horizontally	....	Ibid.	Id.	Ibid.
...rpendic. down from 2° N. of Sword-handle in Perseus.	Two other small meteors.	Ibid.	Id.	Ibid.
...om the direction of 2° under γ Cassiopeiæ, passing 1° below Polaris.	....	Ibid.	Id.	Ibid.
...ll perpendic. down from 2° S. of Polaris.	....	Ibid.	Id.	Ibid.
...rpendic. down from midway between α and β Andromedæ.	....	Ibid.	Id.	Ibid.
...rpendic. down from 10° S. of Polaris, and from the same altitude as Polaris.	....	Ibid.	Id.	Ibid.
...arting from just above Atair, and falling down just W. of the Galaxy. Another small meteor.	....	Ibid.	Id.	Ibid.
...oved from 21° Pegasi to 56° Antinoi.	....	Ibid.	Id.	Ibid.
...om τ Andromedæ horizontally towards the S.	....	Ibid.	Id.	Ibid.
...om just above α Persei, nearly perpendic. down, inclining E.	....	Ibid.	Id.	Ibid.
...ll nearly perpendic. down, inclining to E. and passing 30′ E. of η Aquarii.	....	Ibid.	Id.	Ibid.
...om γ Pegasi perpendic. down, inclining to E.	....	Ibid.	Id.	Ibid.
...om α Cygni perpendic. down towards N.W. horizon.	....	Ibid.	Id.	Ibid.
...om direction of Cassiopeia passing through nebula of Andromeda.	....	Ibid.	Id.	Ibid.
... Cetus	....	Ibid.	Id.	Ibid.
...own from near ε Aquarii	....	Ibid.	Id.	Ibid.
...om 1° below ε Cassiopeiæ down at an angle 50° towards N. horizon. Moved over 10° of space.	....	Ibid.	Id.	Ibid.
...oved horizontally 1½° above Polaris.	....	Ibid.	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1855.	h m s				
Aug. 10	12 6	=4th mag.*	....	Train	....
	12 9	=2nd mag.*	....	Train	....
	12 9 30...	=2nd mag.*	Blue............	Streak	Rapid ....
	12 13	=3rd mag.*	....	Train	....
	12 23	=3rd mag.*	....	....	....
	12 31	=2nd mag.*	Colourless ...	No streak	Not visible 0·3 s
	12 39	Small	....	....	....
	12 39 30...	Small	....	....	....
	12 43	=2nd mag.*	Colourless ...	Leaving a streak behind...	....
	12 47	=1st mag.*............	Red	Streak	Rapid ....
	12 49	Small	....	....	....
	12 53	Small	Colourless ...	Streak	....
	12 56	Small	....	....	....
	12 59	=2nd mag.............	*Red*, yet leaving a *white streak*.	....	....
	1 3 a.m.	=3rd mag.*	Red	Streak	....
	9 47 p.m.	=1st mag.*............	....	Streak	....
	9 58	Small	....	....	....
	10 30	Large	....	With a streak	....
	10 44	Large	....	With a streak	....
	11 0	Several small meteors	....	....	....
	11 0 15...	=1st mag.*............	Blue............	Streak, which lingered ...	....
	11 0 20...	Small	....	....	....
	11 4	....	....	Streak	....
	11 4 30...	....	....	Streak	....
	11 5	Small	....	....	....
	11 8	....	Colourless ...	....	Very rapid. ration 0·5 se
	11 3	Upwards. =3rd mag.*	....	Streak	Rapid ....
	11 4	Down, =3rd mag.*	....	Streak	Rapid ....

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
rom 2° below and 1° N. of β Persei. Moved 30′ of space.	....	Observatory, Beeston.	E. J. Lowe	Mr. Lowe's MS.
own from 1° N. and 10° below Capella.	....	Ibid................	Id.	Ibid.
rom 5° below and 10° N. of β Persei down towards N. at angle of 60°.	....	Ibid................	Id.	Ibid.
rom 1° below and 15° N. of β Persei down towards N.	....	Ibid................	Id.	Ibid.
own in N. from 10° above horizon.	....	Ibid................	Id.	Ibid.
rom head of Dragon down towards W. Moved over 40° of space.	....	Ibid................	Id.	Ibid.
elow β Persei	....	Ibid................	Id.	Ibid.
n Ursa Major.....................	....	Ibid................	Id.	Ibid.
rom 10° E. and 2° higher than Polaris, ending at 2° E. of Polaris.	....	Ibid................	Id.	Ibid.
rom direction of Polaris, starting 10° below Polaris and moved down towards E. at angle of 60°.	Circular	Ibid................	Id.	Ibid.
ow in N.	....	Ibid................	Id.	Ibid.
rom direction of 1° above β Persei, horizontal, passing to Polaris.	....	Ibid................	Id.	Ibid.
own from Perseus to near Pleiades.	....	Ibid................	Id.	Ibid.
early horizontal, inclining down, moving towards S., and passing 5° below β Arietis.	....	Ibid................	Id.	Ibid.
tarting midway between α Persei and α Arietis, and ending 6° N. of α Arietis.	....	Ibid................	Id.	Ibid.
rom β Cygni down towards W.	....	Ibid................	Id.	Ibid.
verhead..........................	....	Ibid................	Id.	Ibid.
own in N.W.	....	Ibid................	Id.	Ibid.
own in N.W.	....	Ibid................	Id.	Ibid.
....	....	Ibid................	Id.	Ibid.
ell from γ Urs. Min. to near γ Bootis.	....	Ibid................	Id.	Ibid.
own through Corona Borealis.	....	Ibid................	Id.	Ibid.
p from χ Cassiopeiæ	....	Ibid................	Id.	Ibid.
orizontally, passing immediately above Polaris.	....	Ibid................	Id.	Ibid.
pwards from Sword-handle of Perseus.	....	Ibid................	Id.	Ibid.
ive small meteors within one minute, four in Pegasus and one from β Andromedæ, which moved towards Cassiopeia, fading when 2° S. of β Cassiopeiæ. This was curious; it had a rolling motion, left no streak, but was itself a collection of rounded bodies each equal to a 4th mag.*, and about 16 in number.	.... 	Ibid................	Id.	Ibid.
Cassiopeia	....	Ibid................	Id.	Ibid.
Cassiopeia	....	Ibid................	Id.	Ibid.

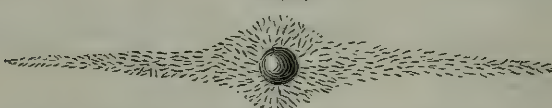
Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1855.	h m s				
Aug. 10	11 5	Down, =3rd mag.*...	....	Streak	Rapid ....
	11 6	Up, =3rd mag.*	....	Streak	....
	11 6	Horizontal, =3rd mag.*	....	Streak	....
	11 10	=2nd mag.*	....	Streak	Rapid ....
	11 14	=3rd mag.*	....	....	....
	11 14 30...	=3rd mag.*	....	....	....
	11 20	Became overcast.			
12	12 48 a.m.	=1st mag.* in brightness, and twice size of 1st mag.*	Colourless ...	Long streak..................	Duration 1 sec. .
	1 5	Another shone through cloud =1st mag.*	....	....	....
	10 20 p.m.	= 1st mag.* but brighter.	Yellowish ...	Long streak..................	Lasted 1 sec. ...
	10 24 30...	=3rd mag.*	Blue............	Streak	Rapid ....
	10 25	=3rd mag.*	....	Train	Rapid ....
	10 28	=3rd mag.*	Red	Streak	....
	9 45 p.m.	=1st mag.*............	Colourless ...	Long streak..................	....
	11 48 p.m.	=1st mag.*............	....	Streak	....
	11 48 10...	=3rd mag.*	....	Streak	....
	11 55 30...	=3rd mag.*	Colourless ...	Streak	....
	11 55 31...	=3rd mag.*	Red	Streak	Rapid ....
13	12 9 a.m.	=3rd mag.*	Red	Tail	Rapid ....
	12 57	=3rd mag.*	Red	Streak	Rapid ....
	12 58	=2nd mag.*	Colourless ...	Streak	....
	1 0 a.m.	=2nd mag.*	....	Streak	....
	1 3	=2nd mag.*	Colourless ...	Streak, which lingered 2 secs. after the meteor had disappeared.	....

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
ı Cassiopeia	....	Observatory, Beeston.	E. J. Lowe	Mr. Lowe's MS.
rom Sword-handle of Perseus.	....	Ibid..................	Id.	Ibid.
rom γ Cygni......................	....	Ibid..................	Id.	Ibid.
own from α Pegasi. Three other small meteors having tails.	....	Ibid..................	Id.	Ibid.
cross from direction of Perseus towards Polaris.	....	Ibid..................	Id.	Ibid.
rom Cassiopeia towards Polaris.	....	Ibid..................	Id.	Ibid.
hone through thin clouds, and passed across a small opening. Moved tolerably rapid from about γ Andromedæ towards Polaris, fading in thick cloud about 10° S.E. of Polaris and at nearly same elevation.	....	Ibid..................	Id.	Ibid.
ell *down* below Cassiopeia. Between this and $1^h\ 15^m$ several others imperfectly seen, after $1^h\ 15^m$ overcast.	....	Ibid..................	Id.	Ibid.
ell perpendic. down along N. side of Galaxy from ϑ Serpentis.	....	Ibid..................	Id.	Ibid.
cross zenith, from β Cassiopeiæ towards Cygnus.	....	Ibid..................	Id.	bid.
pwards from Cassiopeia	....	Ibid..................	Id.	Ibid.
om *exactly* Polaris, perpendic. down 12° towards N. horizon.	....	Ibid..................	Id.	Ibid.
hone through thin clouds from about β Cygni towards S.W.	....	Ibid..................	Id.	Ibid.
own from Sword-handle of Perseus towards S.	....	Ibid..................	Id.	Ibid.
ı Pegasus	Two other meteors.	Ibid..................	Id.	Ibid.
orizontally from half-way between Sword-handle of Perseus and Cassiopeia, moved towards Perseus.	....	Ibid..................	Id.	Ibid.
orizontally in an opposite direction to the last, starting at β Andromedæ.	....	Ibid..................	Id.	Ibid.
arting 30′ below β Andromedæ, and passed 2° below α Andromedæ.	....	Ibid..................	Id.	Ibid.
om 10′ W. of Polaris, perpendic. down.	....	Ibid..................	Id.	Ibid.
om 10° above α Draconis, and passing through this star and fading 5° below it.	....	Ibid..................	Id.	Ibid.
om ½ between Capella and Ursa Major, horizontally.	....	Ibid..................	Id.	Ibid.
oved from 30′ S. and 2° below α Cassiopeiæ horizontally towards S.	....	Ibid..................	Id.	Ibid.

Date.	Hour.	Appearance and magnitude.	Brightness and colour.	Train or sparks.	Velocity or duration.
1855.	h m s				
Aug. 13	1 3	=4th mag.*	Blue............	Streak	Rapid ....
	1 8	=3rd mag.*	....	Streak	Rapid ....
	1 9	=3rd mag.*	Colourless ...	Streak	Rapid ....
	1 9 30...	=2nd mag.*	Colourless ...	Streak	Rapid ....
	1 10	=3rd mag.*	Colourless ...	Streak	Rapid ....
15	12 43 a.m.	=3rd mag.*	Colourless ...	Streak	Rapid ....
	12 44	....	....	....	....
	12 45 30...	....	....	....	....
16	12 10 a.m.	....	....	....	....
	10 45 p.m.	=3rd mag.*	....	Long train	Rapid ....
17	12 45 a.m.	=3rd mag.*	Red	Streak of light...............	Duration 0·5 sec.
22	10 45 p.m.	=3rd mag.*	Colourless ...	Streak	Rapid ....
Sept. 3	10 14	Two small meteors with streaks.	....	....	....
4	8 30	=1st mag.*............	Red	Having a long train of light.	Duration 0·2 sec.
	8 32	=3rd mag.*	Colourless ...	....	Rapid, instantaneous.
	8 50	=1st mag.*............	....	Train	Rapid ....

APPENDIX.

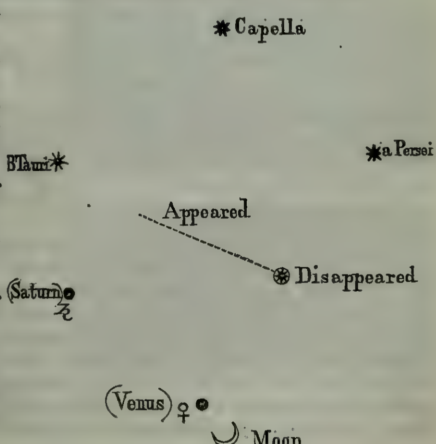
No. I.



Mr. Ansell describes the appearance of the fire-ball as of intense brightness, its colour being a clear and vivid white, and refers the cause of its dazzling brilliance to its intense ignition in passing through the earth's atmosphere; comparing it with the well-known experiment of fusing and even volatilizing iron by means of the oxy-hydrogen blow-pipe, he says its light and accompanying scintillations were of precisely the same character as those produced in the experiment alluded to, and he has very little doubt that they were actually the same. The metallic iron which we know enters largely into the composition of aërolites having become heated and subsequently fused, produced so intense an ignition that explosion necessarily followed. The appearance witnessed was exceedingly beautiful. The drawing at the head of this article represents the meteor at the moment of explosion.

Direction or altitude.	General remarks.	Place.	Observer.	Reference.
orizontally through Cassiopeia towards S.	....	Observatory, Beeston.	E. J. Lowe, Esq.	Mr. Lowe's MS.
rom Cassiopeia through the Dragon's tail.	....	Ibid................	Id.	Ibid.
rom β Arietis moved 10° in the direction of the Pleiades.	....	Ibid................	Id.	Ibid.
rom Cassiopeia towards Vega.	....	Ibid................	Id.	Ibid.
rom direction of Cassiopeia passing 5° N. of Vega.	....	Ibid................	Id.	Ibid.
rom about H. 1 Camelopardi down towards N. at angle of 45°.	....	Ibid................	Id.	Ibid.
similar one S. of π Draconis.	....	Ibid................	Id.	Ibid.
similar one near λ Draconis.	....	Ibid................	Id.	Ibid.
mall meteor in zenith	Very few to-night.	Ibid................	Id.	Ibid.
loved from direction of α Persei, passing 1° under α Arietis and 1° under γ Arietis.	....	Ibid................	Id.	Ibid.
loved from immediately under β Andromedæ and passed 1° above γ Andromedæ.	....	Ibid................	Id.	Ibid.
own towards W. at angle of 45°, passed 10′ W. of ζ Ursæ Majoris.	....	Ibid................	Id.	Ibid.
ı Cassiopeia	....	Ibid................	Id.	Ibid.
loved rapidly from Polaris perpendic. down.	....	Ibid................	Id.	Ibid.
loved down the W. edge of the Galaxy from 5° below the altitude of Atair.	....	Ibid................	Id.	Ibid.
assed downwards through the centre of the Great Bear.	....	Ibid................	Id.	Ibid.

No. II.—*Diagram of the meteor observed by* Mr. J. WATSON.



No. III.—In the Philosophical Magazine, Nov. and Dec. 1854, there is a valuable paper by R. P. Greg, Esq., containing the details of a communication "On Meteorites or Aërolites," which that gentleman gave in a brief form at the Liverpool Meeting of the British Association, 1854. It is much to be regretted that the valuable catalogue which it includes was not communicated so as to form a part of the Report.

A subsequent paper by the same author, Phil. Mag. July 1855, contains a curious and interesting account of some other meteorites.

With a view to *theory*, no student should fail to read two valuable and elaborate papers in the Transactions of the American Philosophical Society of Philadelphia, vol. viii. part 1. 1841, new series, viz. Art. VIII.—"On the Perturbations of Meteors approaching the Earth," by B. Pierce, M.A., and Art. IX.—"Researches concerning the periodical Meteors of August and November," by Hans C. Walker, A.P.S., containing investigations of the nature of the orbits of such bodies about the sun, occasionally encountering the earth.

No. IV.—*Extracts of letters from R. P. Greg, Esq., to Professor Powell, dated Sept. 4th and Sept. 9th,* 1854.

"1844, Oct. 8th, near Coblentz, a German gentleman (a friend of Mr. Greg's), accompanied by another person, late in the evening, after dark, walking in a dry ploughed field, saw a luminous body descend straight down close to them (not 20 yards off), and heard it distinctly strike the ground with a noise; they marked the spot, and returning early the next morning as nearly as possible where it seemed to fall, they found a gelatinous mass of a greyish colour so viscid as 'to tremble all over' when poked with a stick. It had no appearance of being organic. They, however, took no further care to preserve it."

"In connexion with the passage of luminous bodies across the field of a telescope observed by the Rev. W. Read (Report 1852, p. 235), Mr. Greg mentions that a friend of his (whose name he does not give) observed an apparently similar phænomenon, May 22nd, 1854. With a 5-inch object glass equatorial telescope with clockwork, looking for Mercury about 11 o'clock, then little more than an hour from the sun, he saw a luminous body about the size and appearance of Mercury cross the field close to Mercury, with a perfectly round and distinct disk; about a minute after another followed in the same path with about the same velocity (crossing the field in about $2\frac{1}{2}$ seconds by counting the beats of the clock), with an elongated form like a comet; in a few minutes another followed, smaller and round, with the same direction and velocity. They went N.E. and S.W., and appeared going to the sun. It would have taken Mercury 50 seconds to cross the field; the telescope being disconnected with the clockwork. He has never before or since seen a similar phænomenon."

No. V.—*Account of the Meteor of Sept.* 30, 1850, *by Prof. Bond, Cambridge, U.S.*

It rarely happens that an aërolite remains visible to us during a sufficient period of time to enable an observer to trace its path and determine its velocity with anything approaching to the degree of accuracy with which we can, from their slower apparent motion, obtain the same data for the orbits of planets or comets. It is not surprising, therefore, that so little is certainly known regarding the origin of meteors.

Laplace considered it *possible* that they might be fragments of the moon, ejected from some of the numerous craters of our satellite by volcanic power; others have supposed that innumerable smaller masses of dense matter, not in immediate connexion with the larger planetary bodies, might be dispersed throughout infinite space, and occasionally brought within the preponderating influence of the earth. Some persons have believed that meteors were the smaller, as the asteroids may be the larger portions of a planet which formerly occupied a position between the orbits of Jupiter and Mars. Whatever hypothesis may be adopted in regard to their origin, we

must assign to meteors the properties of dense matter, subject to the laws of gravitation; as this fact has been sufficiently established in numerous instances where portions of them have been seen to strike the earth, which upon examination have proved to be solid bodies; the analysis showing them to be, in general, composed of native iron, sulphuret of nickel, quartz and magnesia.

The object of this communication, however, is not to advance any new theory, but to put on record the circumstances which attended the exhibition of the remarkable meteor of the 30th of September, as witnessed at Cambridge.

My attention was called to this phænomenon by Miss Jenny Lind, who happening at the time of its first appearance to be looking at the planet Saturn through the great equatorial telescope, nearly in the direction of the meteor's path, was startled by a sudden flash of light, no doubt much concentrated by the power of the glass; probably not more than a second of time intervened before the meteor exploded, leaving a bright train of light some 8° long, extending from near the head of Medusa towards a point 3° below the star Alpha Arietis, this being the direction of motion, and projecting a portion of its mass forward about 2°, as represented in fig. 1.

Fig. 1.

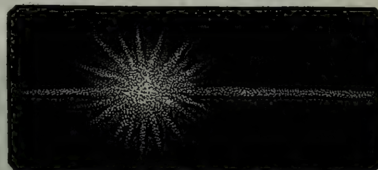


Fig. 2.

Fig. 3.

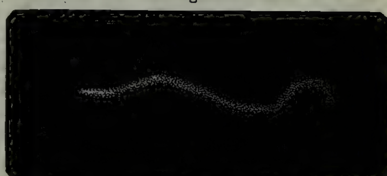


Fig. 4.

This took place at $8^h\ 54^m$ M.S.T. of the Observatory, and in or very near the small constellation "Musca Borealis" in right ascension $2^h\ 30^m$ and north declination 27°. There were numerous radiations, but nothing sparkling in its appearance. At $8^h\ 57^m$ this had subsided into a serpentine figure about half a degree broad in the widest part and 10° long, as seen in fig. 2.

At 9 o'clock the preceding portion had extended upward, curved in the form represented in fig. 3; or as expressed by a person who noticed the same appearance at Framingham, it appeared "to draw up its head like a serpent."

Three minutes later it had assumed the figure given in fig. 4.

During these changes the meteor had continued a bright, conspicuous object, some 10° in length, lying nearly horizontal. It was examined with three different telescopes—the comet seeker, a 4-feet refractor, and the great equatorial. The appearance was that of a con-

gregation of minute, bright clouds, of the formation usually denominated Cirrocumuli.

At $9^h\ 7^m$ we had the regular cometary figure of fig. 5.

Fig. 5.

This, the most durable form, forcibly reminded one of the drawings made by Sir John Herschel of Halley's comet, as seen by him at the Cape of Good Hope on the 28th of January 1836.

The meteor commenced a slow, regular motion, passing about a degree below the star Alpha Arietis, towards a point somewhat above the planet Saturn, at the same time *rotating* apparently on a point answering to the nucleus of the explosion, and expanding in every direction.

At $9^h\ 28^m$ its position in regard to Saturn was as represented in fig. 6, the external outline touching the planet. The meteor was now extended in breadth to 12°, its longest diameter reaching upwards nearly to the zenith. Its *rotary* motion had therefore been equal to an angle of about 90° in 20 minutes of time. Although it had now become a faint nebulous light, yet it continued to exhibit a well-defined boundary until past 10 o'clock, having been under observation more than an hour: I have never met with any account of a single meteor having been visible for so long a time.

Fig. 6.

From the observations communicated by the Hon. William Mitchell of Nantucket, combined with our own, we have ascertained that the vertical height of this meteor above the surface of the earth was about 50 miles, and its distance from Cambridge 100 miles in a north-eastern direction.

We have accounts of its having been seen from near Albany on the Hudson river, Brooklyn, Long Island, Providence, Rhode Island, Nantucket, Manchester, Cape Ann, Portland, Maine, Boscawen, and Peterborough in New Hampshire, Quebec on the St. Lawrence, and the interior stations, Springfield, Quincy, Pepperell, Framingham and Lancaster in Massachusetts, and Norwich in Connecticut.

We have no intelligence in regard to this meteor from Nova Scotia, where it must have been seen if the sky was clear. It is much to be regretted that among the thousands who witnessed this splendid phænomenon, only so small a number regarded it with sufficient interest to note *the direction of motion, position among the stars, and time of its first appearance and duration.*

W. C. Bond.

Cambridge Observatory, Oct. 14th, 1850.

No. VI.—*Account of a Meteor accompanying a Thunder-storm and Earthquake in India.*

[From the *Bombay Times*, Dec. 13.]

A correspondent calls our attention to the fact that in all likelihood Bombay was visited by an earthquake which has been omitted in our enumera-

tion during the furious thunderburst that occurred on the 25th Sept. 1851. He had never then met with anything of this sort; now that he has really felt the sensation created by an earthquake, and reflects on what occurred three years ago, he has no doubt that the former visitation was the same as the latter, but that the violence of the thunder-storm and fury of the rain prevented us from perceiving the tremor, though the sound was heard everywhere. The following is the account given of it at the time:—

"Some singular phænomena occurred during the thunder-storm of Thursday evening, which seem well worthy of record. Exactly at a quarter past ten, when the thunder was at its loudest, the inhabitants of the northern end of the Fort were alarmed with the sound as if of a large mass of something rushing violently through the air—the noise resembling that of a huge cannon-shot passing close by—and immediately afterwards a tremendous crash was heard, as if the mass had impinged on the ground or penetrated some of the buildings; nothing, however, could yesterday morning be discovered in the neighbourhood. The whole closely resembled what is mentioned as having occurred in Rosshire in August 1849, when a huge mass of ice was found to have fallen. The rain was at this time falling so furiously, the night was so dark in the intervals between the flashes of lightning, and these last so bright and frequent, that a meteor of any size might have 'swept unheeded by;' yet appearances look very much as if something of this sort had fallen, and we should recommend observers to be on the outlook for the *corpus delicti*, more than likely at the same time to have dropped into the sea. A tumbler half-full of water, on the sideboard of a house near the Mint, fell in two about seven in the evening, immediately after a vivid flash of lightning! We have it now before us; it is cut almost as clean asunder as if cloven with a knife. The storm abated somewhat after eleven, having apparently gone round to the west and south-west; half an hour after midnight it again got round to the east, and several loud peals of thunder were heard; the lightning throughout was almost continued. Shortly after one all was tranquil again."—*Bombay Times*, Sept. 27, 1851.

"Some further particulars of the fall of the meteor which occurred during the thunder-storm of Thursday evening, noticed in our last two issues, have since then been received. The mighty rushing sound and violent concussion perceived by hundreds of persons in the Fort, was so in exactly the same manner in Colaba, a mile to the southward,—at Ambrolie, two and a half miles to the north-west,—as it was in the Roadstead, a mile to the eastward. All the parties between these two extremes of nearly four miles give exactly the same account of the matter. The sound was said to proceed from the northward as of that of a body passing right over head towards the south, and striking the ground at no great distance. As these phænomena are spoken of by all parties as nearly identical, the meteor must have passed when at its nearest at a distance of ten or twelve miles at least. We want more information on the subject. The smallest contributions will be acceptable. Only one party who has communicated with us actually saw it rush through the air, and observed it fall near the outer light-ship."—*Ibid.* Sept. 30, 1851.

"The writer of the following most interesting notice has our grateful thanks; we trust to hear further of the matter from the Lighthouse, or those on board the outer light-vessel. We have no doubt whatever that this was a meteor or fire-ball of large dimensions which has fallen into the sea:—'It may be of interest to you, with reference to the notice in today's paper of the storm on the night betwixt Thursday and Friday, to know that I was

last evening informed by a seafaring friend of mine, who was, at the time the *Times* describes the *rushing sound* to have been heard, sitting on the deck of a vessel in harbour watching the storm, that he saw what appeared to be an immense mass or ball of electric fluid fall, perpendicularly (as it were) into the sea, apparently near the outer light-vessel: the persons in charge of this craft may probably be able to afford further information.' "—*Ibid.* Oct. 1, 1851.

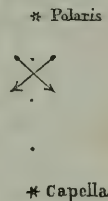
"The following notice of the meteor of Thursday last closely corresponds with what has already reached us: had our correspondent been able to give us anything like an exact idea of the interval which elapsed betwixt the fire-ball being seen and the sound being heard, we might have formed an estimate of the distance of the falling body, if the hissing spoken of was in reality the same as the rushing through the air described by other observers. We shall be happy to receive the future communication our correspondent promises us. 'My wife and I had been watching the lightning for some time at the door of our bungalow, but feeling very much fatigued, being an invalid, I retired to the sofa, and had scarcely done so when my wife called out that she saw a ball of fire fall into the sea in the vicinity of the outer light-ship. The heavens appeared to open at one spot, from which it descended. This took place between the hours of 10 and 11 P.M. Neither of us noticed at that time any particular noise, but at a later hour I said,—Listen to the conflict going on amongst the elements: they seemed hissing one another for some moments.'"—*Ibid.* Oct. 2, 1851.

The fire-ball here referred to was assumed at the time to have been a meteor, and is set down in Prof. Baden Powell's report of that year as one of three which had been observed during thunder-storms, one on the 18th of March in the N.W. Provinces, seen to fall and strike the ground, giving a clear ringing sound like the crack of a rifle, without echo or reverberation at all like thunder. It appeared 150 yards from the Choki, and resembled in its descent a huge ball of red-hot iron, followed by a band of fire apparently about 30 feet in length: another was visible at Kurrachee on the 30th of April in the same year. It burst with a violent explosion during a storm of wind and rain, resembling the discharge of a vast battery of artillery; about a minute afterwards a great ball of fire, supposed to be a meteor, was seen descending into the sea—the third case being that of the 25th September already quoted. Departing from the question of earthquakes, we now come to the conclusion that these balls of fire, supposed to have been meteors, were in reality instances of "the glow discharge" mentioned by Sir William Snow Harris, and that they are matters of rather frequent occurrence in India. In 1832, in the middle of a violent thunder-storm, a great fire-ball was seen to descend over the house of Sir Colin Halkett near Parell. It burst with a furious explosion, and did much mischief all around, amongst other things melting the plate on the sideboard. On the 16th of June 1819, at the time of the great earthquake, a tremendous thunder-storm occurred at Masulipatam, during which a fire-ball was seen to descend on the roof of a bungalow, when it burst with an explosion like a 40-inch shell, and immediately set the thatch in a blaze. These two last cases which we have quoted, one of which occurred during an earthquake, certainly were electric explosions, and they in all respects so closely resemble the others heretofore supposed to be meteors, that we think we are perfectly safe in assuming the phænomena to have been the same, and that Prof. Powell's Bombay correspondent was in error on the matter.

No. VII.

Observatory, Beeston, near Nottingham, Sept. 4, 1855.

MY DEAR SIR,—The Rev. K. Swann, of Gedling near Nottingham, has sent me an account of two meteors whose paths crossed each other; they started from a point between Polaris and Capella, but only a third of the distance from Polaris. The first was of the 1st magnitude and the second of the 2nd magnitude; both moved rapidly, were colourless, and had no trains of light. The paths were about 5° in length. Mr. Swann sent the following sketch :—



Believe me, my dear Sir, yours very truly,

E. J. LOWE.

Observatory, Beeston, near Nottingham, Sept. 4, 1855.

MY DEAR SIR,—Yesterday I posted for the British Association Report on Meteors a list of those which have been noticed here during the past twelve months. To that report I have to add a few remarks.

In 1855 the meteors on the 9th and 10th of August were very numerous. The evenings of the 10th and 11th were mostly cloudy, but many meteors were noticed on the 12th.

There were two large meteors observed on the 3rd, and it is worthy of note, that, although the number of these bodies in the first week of August are not nearly so numerous as they are a week later, still larger meteors are seen about the 3rd of August than about the 10th; this I have noticed in other years. Of 118 meteors seen between the 9th and 13th of August 1855,

15 were of the 1st magnitude,
22 were of the 2nd magnitude,
30 were of the 3rd magnitude,
51 were of smaller magnitude.

In 42 examples of these meteors,

17 were colourless,
17 were blue,
7 were red,
1 was yellow.

Nearly all the meteors had streaks, which lingered after the meteors had themselves vanished.

At a fair estimate I could not have seen more than a third of the meteors that fell, consequently they were falling at the following rate per hour:—

August 9th from 10 to 11 p.m.=150,
10th from 12 to 1 a.m.=48,
10th from 10 to 11 p.m.=56,
$\left.\begin{array}{l}\text{12th from 10 to 12 p.m.}\\\text{13th from 12 to 1 a.m.}\end{array}\right\}=40,$

an average between the 9th and 13th of 73 per hour, which would give for the five days the extraordinary number of 8760.

On producing the paths of their course *backwards*, several points of divergence were well shown on the 9th, 10th, 12th and 13th.

The one most apparent was $\frac{1}{2}$° above and 2° N. of α Persei; a second well shown was 2° N. of the cluster of stars in the Sword-handle of Perseus; a third immediately under Cassiopeia; and a fourth below χ Cygni.

A very large proportion of the meteors were at one portion of their path within 10° of an imaginary line drawn from Cassiopeia to Cygnus.

The majority moved very rapidly.

The points of divergence in Cassiopeia and Cygnus were noticed in former years, but the two in Perseus were not seen until 1855, and I cannot help thinking that the meteors in other years (that I have observed) did not show these points of divergence in Perseus.

It will be well to call the attention of observers to this fact, in order that it may be carefully watched.

Believe me, my dear Sir, yours very truly,

E. J. LOWE.

To the Rev. Professor Baden Powell, F.R.S. &c.

Provisional Report of the Committee, consisting of Mr. W. FAIRBAIRN, His Grace the Duke of ARGYLL, Captain Sir EDWARD BELCHER, *the* Rev. Dr. ROBINSON, *the* Rev. Dr. SCORESBY, Mr. Joseph WHITWORTH, Mr. J. BEAUMONT NEILSON, Mr. James NASMYTH, *and* Mr. W. J. MACQUORN RANKINE; *appointed to institute an inquiry into the best means of ascertaining those properties of metals and effects of various modes of treating them which are of importance to the durability and efficiency of Artillery; and empowered, should they think it advisable, to communicate, in the name of the Association, with Her Majesty's Government, and to request its assistance.*

AT the time of the meeting of the British Association, at Glasgow, in September last, a question arose in the Mechanical Section as to the causes of the deterioration of the metal of which the Artillery of the present day was constructed. On this question a long and interesting discussion ensued, both in reference to the comparative weakness of cast iron as now produced, and to the adaptation of forged and malleable iron, as being stronger and better adapted for the purpose than the former.

Accounts received from the Baltic and from the Black Sea of the bursting of guns and mortars of recent construction (for which the inferiority of the metal from which they were cast was the reason assigned), afford evidence of something wrong. These failures gave rise to conjectures and uneasiness on the part of the Government as well as the public, and in order to trace the cause of this apparent weakness to its source, an inquiry was instituted by the authorities at Woolwich, and, subsequently by the Association, in the appointment of this Committee to co-operate with Her Majesty's Government in the investigation of this very important question. In order that no time might be lost, the Secretary of the Section was directed to issue circulars to engineers, ironmasters and manufacturers, requesting that they would forward to the members of the Committee such opinions and observations as they deemed advisable, in regard to the material itself and to its treatment preparatory to the manufacture of ordnance.

To these applications replies have been received from Sir Edward Belcher, Mr. Nasmyth, Mr. Neilson, Mr. Fairbairn, and others, of which the following are extracts:—

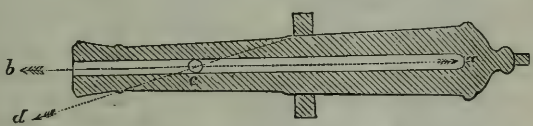
Extracts from a letter addressed to the Committee by Sir Edward Belcher, dated Glasgow, Sept. 19th, 1855.

Sir Edward observes that, in gunnery practice, the interposition of grit and

the oxidation of the shot, especially with undue rapidity of firing, soon change the central axis; and alludes to the grooved and abraded state of the guns which have been returned, in proof of his assertion. He points out the necessity of experiments to ascertain how much of the heating of the gun is due to friction, and urges that, for special service at any rate, polished shot accurately fitting the gun should be provided. He points out the great efficiency of the guns used at the siege of Gaeta, in 1815, in which he took an important part; and considers that some guns of that date should be examined and the quality of the metal of which they are composed, ascertained. He believes that the greater heat at which metals are now fused, and the more perfect fluidity attained, facilitate an undue rapidity of crystallization, and, according to his idea, impair the cohesive strength of the metal. In consequence of the vents giving way before the bore is injured, he proposes the use of screw vents, $1\frac{1}{2}$ inch in diameter, and as hard as fowling-piece nipples. He considers that even the whole breech might be cast separate, of a denser material than the rest of the gun; and that this is proved by the ancient forms of guns, by the Chinese gingals, and by the revolving rifles and pistols of Colt and Adams. In conclusion he affirms that four-fifths of the present expense might be saved by the use of the best guns our engineers can produce.

There is some truth in Sir Edward's remarks on the abrasion or grooving of the gun. The two opposite forces of propulsion and recoil act equally on the breech as on the ball, but in different directions; and if the ball does not accurately fill the bore, it has a tendency to expend part of its force on the sides of the gun, and to cause rupture near the trunnions. Under such circumstances, the gun is subject to several distinct strains: one on the

Fig. 1.



breech in the direction of the arrow a; another in the line of the bore in the direction of the arrow b; and a third from the pressure of the ball upon one of the sides as at c, causing a strain in the direction of the arrow d. These forces, when in action at the same time, tend to rupture the gun at the trunnions, by tension on the line of discharge a b, and by a transverse strain at c, caused by the pressure of the ball in the direction of the line d. In guns of great length, a perfectly true bore and an oblong or cylindrically turned ball, fitted like the piston of a steam-engine, would doubtless cure this defect and prove advantageous, by giving greater safety to the gun, by diminishing the friction, improving the windage, and ensuring a more direct line of flight to the projectile. There are difficulties in casting and fitting guns on this principle, which may however be overcome by strict attention to sound rules of construction.

Extracts from a letter addressed to the Committee by Mr. James Nasmyth, dated Patricroft, Sept. 19th, 1855.

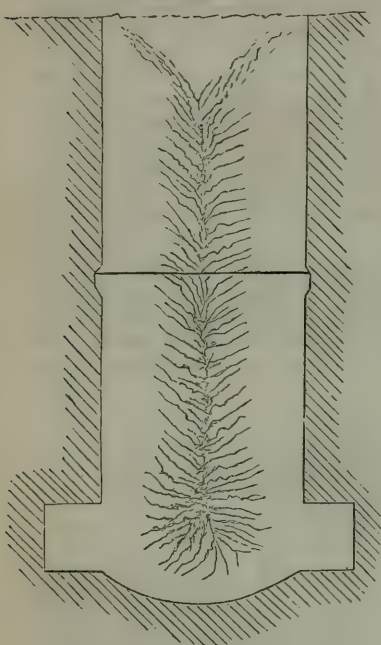
Mr. Nasmyth, so well known as the inventor of the steam-hammer, commences his letter by entering on the subject of the failure of malleable iron guns. He states that those which are built of bars, welded together, are sure to be destroyed sooner or later by the continued disruptive force of the

explosion of powder in the chamber ; that it is still a question, whether, with our present means of forging large masses of iron, we may not obtain powerful forged iron guns; but so great is the difficulty of obtaining a sufficiently large mass of iron sound in every part, so great is the expense arising from loss of material by oxidation, and such is the tendency to basaltic crystallization

Fig. 2.

Diagram to illustrate the effects of casting solid, the interior being weak and spongy.

Vertical section.



Horizontal section.

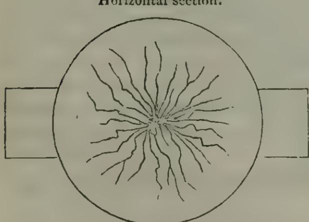
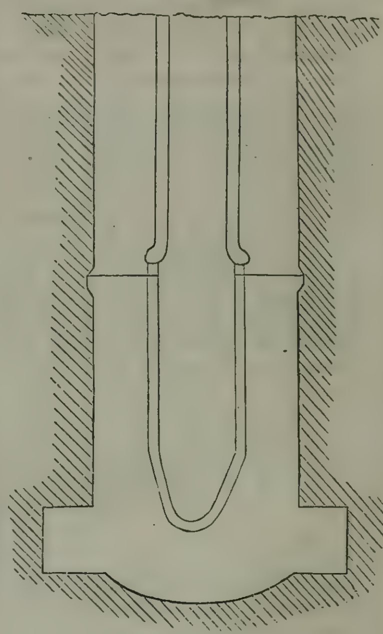


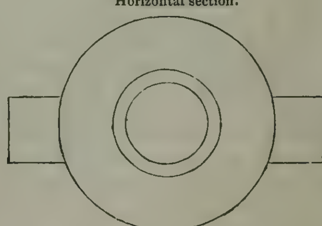
Fig. 3.

Mr. Nasmyth's method of casting mortars with a malleable iron chamber.

Vertical section.



Horizontal section.



which the long-continued heating produces, that Mr. Nasmyth comes to the conclusion, that powerful ordnance cannot be manufactured advantageously

of malleable iron,—a candid admission on the part of one whose exertions in that direction are so well known.

Mr. Nasmyth then refers to the failure of cast-iron guns of recent construction. This he attributes principally to two causes: first, to the use of iron smelted and cast by coal; and secondly, to the modern method of casting without a core. The superiority of Russian and Swedish guns, proved by the late war, he ascribes to the use of iron prepared by *wood fuel*; coal in all cases detracting from the tenacity of iron by contaminating it with sulphur. For this reason, hot-blast iron, smelted by raw coal, is inferior to cold blast, which is smelted by coke from which many of the impurities of the coal have been driven off. He believes that the present method of casting without a core causes the centre or last-cooled portion to be spongy and deficient in density and strength. To secure the greatest density and tenacity in the centre, the present mode must be reversed, and,—as, according to his statement, has long been practised in Russia, Sweden and the United States,—must be cooled from the centre outwards. Mr. Nasmyth proposes that the core should consist of a malleable iron chamber, kept cool by a current of air or by a stream of water. In this way he thinks we shall obtain increased density of metal where it is most wanted, and he hopes fully to prove the correctness of his views by the construction of a mortar of great strength and range, now in progress. In conclusion, he points out the unfitness of the spherical form for a missile expected to reach its destination with precision, on account of its susceptibility to slight disturbing causes. He considers the Minié bullet, especially when axial rotation is imparted, to possess all the conditions required to give efficiency to a projectile.

In addition to the above, we may observe that most of Mr. Nasmyth's objections to wrought iron apply also to steel: for although it can be cast and run into moulds, and can afterwards be rendered malleable by the strokes of a powerful hammer, with some degree of certainty; yet, looking at the results of the attempt to produce a 68-pounder gun, made by one of the most distinguished steel manufacturers in Europe, Herr Krupp, of Essen in Prussia, and taking into consideration the enormous cost, we may conclude that this valuable material is not calculated to supplant cast iron in the manufacture of ordnance.

With regard to Mr. Nasmyth's opinion on the subject of casting with a core, undoubtedly great advantages would result if it could be accomplished. But in this process many obstacles have to be surmounted, arising from the difficulty of regulating the rate of cooling on the exterior and interior surfaces, and from the obstacles in the way of boring after a core. This process has often been tried in this country, but in practice has generally been found unsuccessful. In America and in France it has also been attempted, but we have yet to learn, whether the artillery of those countries is actually cast in this way.

Mr. Cochran, of the United States, has a patent for the water-core system, but we have been unable to ascertain to what extent it has been successfully put in practice. Casting in chill is another process also beset with difficulties; some experimental trials made at St. Helens during the last six months show that great uncertainty exists as to the result. Further experiments, however, and a more extended practice may eventually remove the difficulties.

Extracts from a letter addressed to the Committee by Mr. J. Beaumont Neilson, dated Glasgow, Sept. 20th, 1855.

Mr. J. B. Neilson, the inventor of the hot blast, who has had great experience in casting metals, recommends that guns, if made of wrought iron,

should be forged upon a mandril in a series of rings, welded successively one upon another, till the required length is completed. He is of opinion that the hot blast has enabled the manufacturer to produce iron from inferior materials, and that quantity, not quality, is chiefly aimed at by the smelter. He considers, however, that if premiums were offered for the best and strongest qualities of iron, Government would soon have metal of the required tenacity. He recommends that guns be cast hollow with cores artificially cooled. He thinks that it would be advantageous to cast a number of bars about 2 feet long and 2 inches square, in moulds of various materials, as in green-sand, dry-sand, loam, in chill, and in cast-iron moulds at 500° of temperature, in order that the effects of different rates of cooling might be observed and the best quality selected.

The next communication is from Mr. Fairbairn, addressed to His Grace the Duke of Argyll, a member of the Committee, dated Cardross, Perthshire, Sept. 27th, 1853. This letter was submitted by His Grace to the Minister for War, and to the Select Committee at Woolwich.

Mr. Neilson's communication to the Mechanical Section, "On Forging large Masses of Malleable Iron," proved that the strength and other properties of wrought iron are seriously injured by repeated heatings, that there is a considerable loss by oxidation, and that the cost and risk are great. These considerations, and others arising from the physical properties of wrought iron, its ductility and want of elasticity, clearly show that it is not a material adapted for the construction of heavy ordnance.

We must therefore inquire, what material at our disposal is best calculated to ensure durability and strength for heavy guns. Cast steel is expensive, and hitherto has not been manufactured on a sufficiently large scale to ensure its application. We have therefore to choose between brass gun-metal and cast iron. The latter appears by far the more eligible, both as regards its density and cost, and it opposes almost as much resistance to strain. The failure of recent cast-iron guns arises from the employment of an unsuitable description of that material, and from errors in their manufacture.

It is our opinion that guns of the very best quality can be manufactured in this country, provided that more care is taken in smelting and casting; that cold-blast iron, smelted with coke free from sulphur, is used; and that a proper selection of flux and ore is made. The introduction of the hot blast has given great facilities not only for the reduction of crude ores of inferior quality, but at the same time it enables the manufacturer to melt down cinder heaps and other impurities which cause the iron produced to exhibit all the conditions of porosity and weakness. On this account hot-blast iron should be absolutely prohibited in the manufacture of ordnance; there is no excuse for its employment, as we are confidently assured, that several makers are prepared to supply Government with any quantity of the required description at a proportionate rate of cost. Careful selection of the material and attention to its treatment are only therefore required to produce iron suitable for guns of any power or strength.

Being satisfied on these points, we have next to consider how to make use of the material to produce guns of a maximum strength. The contraction that a large mass of metal undergoes, in becoming solid, is known to have a very injurious effect on its tenacity and strength. In casting guns, as at present managed, the cooling process proceeds from the exterior to the interior, and the consequence is that the central portion is porous and to a great extent devoid of density and cohesion. It does not require much practical skill to know that the use of a core would remedy this defect; and

provided this could be accomplished and the core kept cool by a current of air or water, as is said to have been done in America, considerable improvement as regards strength would be effected. If these suggestions were acted on, the Government of this country would doubtless have guns of as great strength and range as any other nation; and it would be a disgrace to us, if, with our boasted skill and vast experience in the treatment of metals, we could not surmount a difficulty which should never have existed, and which only requires the attention of practical men to place it on a more satisfactory footing.

In all descriptions of artillery the strain in the chamber of the gun is enormous. This is evident when we consider that the ball leaves the gun with a velocity of 1800 to 2000 feet per second, and that the force which gives this immense velocity acts equally on the breech of the gun as upon the ball. From these data we must learn to apportion the metal to the several parts in the ratio of the strain they have to bear.

The length of the bore is another important point, as, within certain limits, the range depends upon the time during which the expansive power of the gases of the explosion is acting upon the ball, or in other words, on the length of the bore. Increasing the length of the bore increases the range, or, what is the same thing, diminishes the amount of powder necessary to project the ball to a given distance.

One of the causes of failure, in both ancient and modern artillery, is the abrasion of the lower part of the vent by repeated discharges. In modern guns this is perhaps more injurious, on account of the porous state of the metal at that part arising from casting solid. To remedy this defect it is important to increase the density of the metal, and if possible to case-harden the entire inner surface of the gun. To attain this we have already intimated that ordnance be cast in chill; that is, should be cast on accurately turned metallic cores, at such a temperature as is best calculated to secure the object in view. To obtain uniformity in the rate of cooling round this core, and to produce a hard skin of steeled iron over the whole interior of the gun, the core should be hollow, and a current of air or water conducted through it. This process would secure much greater strength and durability to ordnance, and at the same time cheapen its construction.

In a former part of this Report we referred to the process of casting in chill (*vide* page 103). This is a process well worthy of the attention of the Government, as a series of accurately conducted experiments, with proper apparatus, would, in our opinion, lead to important and highly satisfactory results. At St. Helens experiments of this nature were made by Messrs. Robinson and Cook under the immediate superintendence of Mr. Fairbairn; and judging from the results of some of the castings, there did not exist a doubt as to the advantages to be derived from the system if properly carried out. Several guns, or rather cylinders, of the same proportionate thickness of metal were cast; two of them failed, from some irregularities in the cooling, which caused the core or mandril to get fast; another, however, was well cast, with a perfectly smooth, interior skin, case-hardened to a considerable depth by the chill. In this experiment the process was to a great extent successful, and the only difficulty to be encountered was the danger indicated by the failures, of collapse or contraction upon the mandril. The utmost care was required for regulating the rate of cooling upon the mandril to prevent its being unduly heated by the surrounding mass so long retained in a state of liquefaction.

In these experiments sufficient data were established to convince the experimenters that, with proper tools and appliances, this system of casting

ordnance might, with careful management, be introduced; and assuming that this could be done, we have the less hesitation in recommending it to the attention of the Government as eminently entitled to a further extension of experimental research.

If casting in chill were successfully accomplished, artillery would be cast on accurately turned and perfectly true mandrils, so as to chill or case-harden the interior to a depth of about a tenth of an inch. This process would consolidate the metal by a uniform rate of cooling, and entirely dispense with boring. In the attainment of these objects, it must, however, be admitted that many difficulties have to be encountered, such as the cooling of so large a mass of fluid metal without injuring the mandril, and regulating the temperature so as to produce the desired chill. These are points which require minute attention, and must be left to the consideration of the Government and to the unerring test of experiment.

In addition to the numerous suggestions contained in this Report, we may state that experiments are now in progress to ascertain the strength and other properties of a compound similar to meteoric iron, composed of an alloy of about $2\frac{1}{2}$ per cent. of nickel melted with the best cold-blast iron. His Grace the Duke of Argyll has kindly sent a quantity of calcined nickel in order to ascertain the properties of this compound as compared with those of the ordinary mixtures of the best metals. These experiments are not yet complete; but assuming the properties of the mixture to be similar to those of meteoric iron, we should then have a strong and very elastic material for the manufacture of artillery*.

Mr. Joseph Whitworth, in a communication to the Committee, dated September 20, 1855, refers to a rifled cannon, which he is constructing in parts. It consists of three cast- or wrought-iron pieces bound together by wrought-iron rings. The bore is nine-sided, with the requisite pitch for imparting rotatory motion to the ball.

Mr. Fulton, in a communication to the Committee, dated Glasgow, September 29, 1855, offers to undertake the forging of a wrought-iron gun similar to Mr. Nasmyth's, and sends sketches of some very large forgings he is making for Messrs. Scott Russell and Co.'s great vessel, showing what he is able to accomplish :—

	tons	cwt.	qrs.	
Paddle shafts, supposed to be ...	30	0	0	each.
Propeller shaft, supposed	37	0	0	
Intermediate shaft, forged.........	28	13	1	
Crank, forged	10	10	2	
Crank, finished	7	4	0	
Friction strap, supposed	10	0	0	

Extracts from a letter addressed to the Committee by Mr. Macquorn Rankine, dated Glasgow, November 13, 1855.

Mr. Rankine, after referring to the fact that it is extremely difficult to break a brittle earthenware jar if filled with honey, the difficulty obviously arising from the softness and defective elasticity of the honey, which impedes the transmission of molecular vibrations, proposes to imbed the cannon in a thick coating of some soft inelastic metal such as lead.

* Since the above was written, several alloys of nickel and iron have been put to the test of experiment, and have not proved so satisfactory in their powers of resistance to strain and impact as was originally expected.

Extracts from a letter from Mr. David Pilmore of Shoreham, forwarded to the Committee by Mr. John Mackinlay, dated Edinburgh, January 7, 1856.

Mr. Pilmore considers that the inferiority of the iron of the present day is due partly to the source from which it is derived, but chiefly to the manner in which it is smelted. All the iron of the present day contains, according to his statement, phosphuret of iron, amounting, even in the best gray sorts, to $\frac{1}{2}$ per cent.; this salt being derived from the use of coal in smelting. He thinks also that the gunpowder of the present day may differ greatly in its properties from that formerly manufactured. This difference he expects from the fact that the charcoal now used in its manufacture is burnt in closed iron vessels, thus preventing the passage of air through its tissues, which was allowed formerly.

Extracts from a letter addressed to Mr. Fairbairn by Mr. A. Handyside, dated Derby, January 22, 1856.

Mr. Handyside sends the annexed drawings of a mortar and cannon to be made in parts; the material to be wrought iron.

The mortar (figs. 4 & 5) to be made of rings welded together, the whole

Fig. 4.

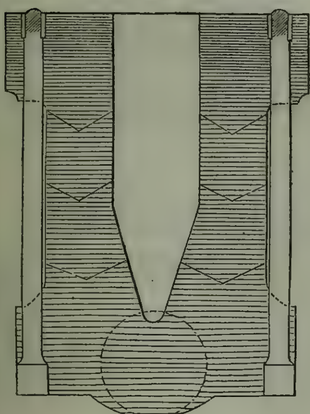


Fig. 5.

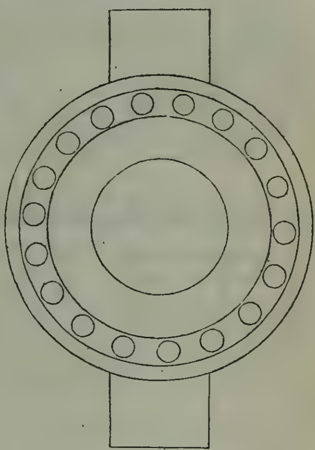
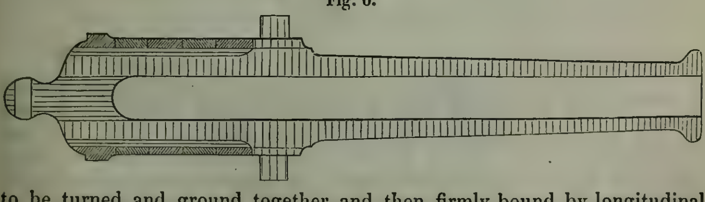


Fig. 6.



to be turned and ground together and then firmly bound by longitudinal bolts. The cannon (fig. 6) to be made in a similar way, the part behind

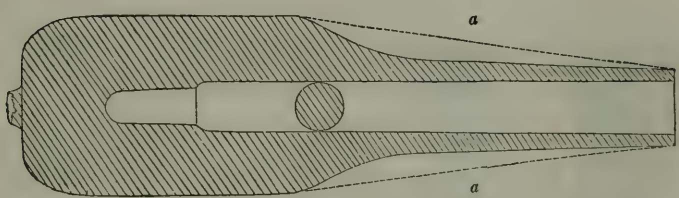
the trunnions slabbed longitudinally and ringed as shown. Mr. Handyside adopted this method in order to make use of wrought iron, as he conceives that they could not be made of it entire. He was led to this plan by having successfully made in this way an hydraulic press cylinder after a cast one had broken. The forged one has stood for six years and is still sound. Others made since in the same way have been equally successful.

It is questionable whether any built gun can long resist the violence of the explosion, and we believe that wrought iron is not the best material for heavy ordnance. Nevertheless, in our opinion, Mr. Handyside's gun and mortar are constructed on a better principle than most we have yet seen.

Extracts from a letter from Mr. Cochran addressed to Mr. Fairbairn. Without date.

Mr. Cochran attributes the failures of ordnance of the present day to the inferiority of the metal and to the defective manner of casting. He would obviate the first by the use of iron from the Acadian mines of Nova Scotia, which he states to be equal if not superior to the celebrated Swedish metal,

Fig. 7.



Gun as now adopted in the United States—from a drawing sent by Mr. Cochran. We think it would be improved if the metal were filled up as far as the dotted lines *a a*.

and is used extensively by the Government of the United States for artillery. The defective mode of casting he would remedy by the use of the water core which he has invented. He encloses the ordinary mould in a case of non-conducting materials so thick as entirely to prevent the passage of heat from the exterior of the casting. To accelerate the cooling on the interior of the casting he uses a hollow core through which he can draw a stream of water or current of air at pleasure.

On Typical Objects in Natural History.

[*Circular.*]

Hitcham, Bildeston, Suffolk,
June 1855.

Dear Sir,

To secure materials for a Report called for by the Natural History Section of the British Association "On a Typical Series of Objects in Natural History adapted to local Museums," I would thank the Members of the Committee to furnish me with the names and addresses of Naturalists whom they know to have paid special attention to particular groups in either the animal, vegetable, or mineral kingdoms. I will then request these parties, as I now do the Members of the Committee, to send me their opinion of

what objects they regard as *most typical* of those groups and their principal subdivisions. May I request that returns be made as speedily as convenient, and that they be not delayed beyond the end of this month, or at furthest the middle of the next?

As an example of what may be considered sufficient for the purpose intended, I here subjoin the information afforded me by Mr. Darwin, whose close study of the Cirripedia has rendered him so competent a judge of what may be regarded as the most typical species of this group of animals.

J. S. HENSLOW.

[N.B.—The list referred to is inserted under *Crustacea.*]

P.S. I would further suggest, that where the *best* type is not a British object, some British species *in addition* (the more common the better), belonging to the same group, should be named. These, being superadded to the typical series, will point out the full extent to which the groups illustrated occur in Britain.

In regard to typical objects for a geological series, I would suggest some such formula as the following to be filled up and forwarded:—

Under each formation, its—

I. Lithology.

1. Typical rock specimens (*ex. gr.* from Red Crag):—
   (1) Comminuted shells, more or less cemented by oxide of iron.
   (2) Detrital materials from the lower beds, viz. rolled and altered fragments of Septaria, phosphate nodules, and a few characteristic fossils from London Clay, from Coralline Crag, &c.
2. Simple minerals frequently associated with the rock series (*ex. gr.* from London Clay):—
   Gypsum (crystals), Iron Pyrites (nodules).
3. Illustrations of volcanic agency:—
   (1) Rocks ejected during the period.
   (2) Rocks modified by eruptions subsequent to the period in question (*ex. gr.* coal charred, limestone crystallized, by incursion of trap in dykes subsequent to the consolidation of the coal-measures).

II. (Botany) FLORA.

Best examples for proving the fact, that either or each of the three Natural Classes have been met with in the formation illustrated:—

(3) Acotyledones.
(2) Monocotyledones.
(1) Dicotyledones.

III. (Zoology) FAUNA.

One species of one or more genera characteristic of the formation in each Class, and its main subdivisions, as,

Classes or Subclasses.	Example of Subdivisions.
Amorphozoa.	
Foraminifera.	
Zoophyta.	
Echinodermata	Crinoïdea. Asteroïdea. Echinoïdea.
Annelida.	
Crustacea	Cirripedia.
Insecta.	

Bryozoa.
Brachiopoda.
Monomyaria.
Dimyaria.
Gasteropoda.
Pteropoda.
Cephalopoda.

Pisces.
Reptilia.
Aves.
Mammalia.

The following Report, with the Lists received, were presented at the Glasgow meeting:—

The late lamented Prof. E. Forbes devoted his Introductory Lecture* at the Museum of Practical Geology, in 1853, to a consideration of the "Educational Uses" of Museums, and he has there commented, with some degree of severity, upon the very inefficient manner in which many local Museums are arranged. Without wishing to extend his censures to Curators who have devoted time and labour to the due arrangement of whatever objects have been placed under their care, we cannot help remarking how inefficient their exertions have proved in respect to the general "educational uses" to which they might have been rendered subservient. Great care may often have been bestowed in displaying numerous species belonging to one or more favourite groups, whilst many others, more or less extensive (tribes, orders, and even classes) among animals, plants, and minerals, are entirely unrepresented.

Although our great National Establishments in London are adapted for displaying a large proportion of all procurable objects of natural history, it would require larger funds than local Museums are likely to command, to adopt the plan which they follow. But it is within the power of every Museum, however humble its pretensions, to procure and display such instructive series of objects as may bring the entire range of natural history in a forcible manner before the attention of the public. Wherever a specimen of some species regarded as a sufficient type of a particular group cannot be conveniently procured, then a model, a drawing, or a tracing from some published figure may be introduced as a substitute. Naturalists often differ in regard to what species they consider the best representatives of certain groups; but still, the judgement of Curators would be greatly assisted in making choice of objects for public display, if they were furnished with lists of types selected by naturalists who had paid special attention to particular groups. If they considered it the primary object of their duty to secure specimens of as many of these types as possible, and to obtain representations (models or figures) of whatever they could not procure, they would possess a basis on which to ground their arrangement of whatever else their Museums contained. There would no longer be great gaps in the general

* On the Educational Uses of Museums (a pamphlet of 19 pp.), by Edw. Forbes, F.R.S. &c. Longman and Co., 1853.

series; but good types of all the main groups in the three great kingdoms of nature would be publicly displayed.

Frequent additions to a general collection necessitate continual rearrangements among the objects deposited in Museums; but a set of horizontal cases on the floor may be advantageously appropriated to the display of the selected types. These will form a sort of "Typical Epitome" of natural history, distinct from the rest of the collection. This Epitome will serve as a general index to the whole; and where a typical specimen (from size or other consideration) could not be ranged in the horizontal cases, a model or figure would occupy its place, accompanied by a reference to the spot where (if it be in the Museum) it may be seen. By a little tact and contrivance, such a Typical Epitome may be reduced within a narrow compass. Very limited Museums might advantageously restrict their collections to little more than a general typical series; always excepting those special collections which are to illustrate the natural history of their own neighbourhoods.

Perhaps the plan of a general circular inviting naturalists to cooperate in furnishing typical series for the departments with which they happen to be best acquainted, has not been so successful as a more special application to individual Members of the Association might have proved. A few, however, have kindly favoured us with lists, and the publication of these may probably prevail with others to assist in completing a scheme which the Natural History Section has twice sanctioned, and which partial experience has proved to be of considerable utility. No Curator can be equally competent in all departments of natural history, to select the types best adapted for illustrating the principal groups* in which genera are ranged.

ANIMAL KINGDOM.

N.B.—In the present imperfect state of the returns, the divisions into Classes, Orders, &c. are retained as the respective authors have employed these terms.

Class MAMMALIA.

No list sent in.

Class AVES.

The types are selected for groups nearly according with the arrangement of Mr. G. R. Gray. List supplied by Philip Lutley Sclater, Esq.

Ordo I. ACCIPITRES.

1. Vulturidæ	*Neophron percnopterus*	B.
2. Falconidæ	*Falco peregrinus*	B.
3. Strigidæ	*Strix flammea*	B.

* Great service will be rendered, if those who furnish the lists, will, as far as possible, give references to good figures of the types selected. A (B) should be placed after such species as occur in Britain.

Ordo II. PASSERES.

a. Fissirostres.

4. Caprimulgidæ	*Caprimulgus europæus*	B.
5. Hirundinidæ	*Hirundo rustica*	B.
6. Coraciadæ	*Coracias garrula*	B.
7. Todidæ	*Todus viridis.*	
8. Momotidæ	*Momotus brasiliensis.*	
9. Trogonidæ	*Trogon curucui.*	
10. Alcedinidæ	*Alcedo ispida*	B.
11. Galbulidæ	*Galbula viridis.*	
12. Meropidæ	*Merops apiaster*	B.
13. Bucerotidæ	*Buceros rhinoceros.*	

b. Tenuirostres.

14. Upupidæ	*Upupa epops*	B.
15. Promeropidæ	*Nectarinia senegalensis.*	
16. Cærebidæ	*Cæreba cærulea.*	
17. Trochilidæ	*Trochilus colubris.*	
18. Meliphagidæ	*Meliphaga phrygia.*	
19. Certhiidæ	*Certhia familiaris*	B.

c. Dentirostres.

20. Sylviidæ	*Sylvia luscinia*	B.
21. Turdidæ	*Turdus viscivorus*	B.
22. Muscicapidæ	*Muscicapa grisola*	B.
23. Ampelidæ	*Ampelis garrula*	B.
24. Laniidæ	*Lanius excubitor*	B.

d. Conirostres.

25. Corvidæ	*Corvus corax*	B.
26. Paradiseidæ	*Paradisea apoda.*	
27. Sturnidæ	*Sturnus vulgaris*	B.
28. Fringillidæ	*Fringilla cœlebs*	B.

Ordo III. SCANSORES.

29. Psittacidæ	*Psittacus erithacus.*	
30. Ramphastidæ	*Ramphastos toco.*	
31. Capitonidæ	*Capito cayanensis.*	
32. Picidæ	*Picus major*	B.
33. Cuculidæ	*Cuculus canorus*	B.
34. Musophagidæ	*Musophaga violacea.*	

Ordo IV. COLUMBÆ.

35. Columbidæ	*Columba palumbus*	B.

Ordo V. GALLINÆ.

36. Cracidæ	*Crax alector.*	
37. Megapodidæ	*Megapodius lapeyrousii.*	
38. Phasianidæ	*Phasianus colchicus*	B.
39. Tetraonidæ	*Tetrao tetrix*	B.
40. Chionididæ	*Chionis alba.*	
41. Tinamidæ	*Tinamus major.*	

Ordo VI. STRUTHIONES.

42. Struthionidæ	*Struthio camelus.*	
43. Apterygidæ	*Apteryx australis.*	

Ordo VII. GRALLÆ.

44. Otididæ	*Otis tarda*	B.
45. Charadriidæ	*Charadrius pluvialis*	B.
46. Gruidæ	*Grus cinerea*	B.
47. Ardeidæ..........	*Ardea cinerea*	B.
48. Scolopacidæ	*Scolopax rusticola*	B.
49. Palamedeidæ	*Palamedea cornuta*..............	B.
50. Rallidæ	*Rallus aquaticus*................	B.

Ordo VIII. ANSERES.

51. Anatidæ..........	*Anas boschas*	B.
52. Colymbidæ........	*Podiceps minor*	B.
53. Alcidæ	*Utamania torda*	B.
54. Procellaridæ	*Procellaria pelagica*	B.
55. Laridæ	*Larus canus*	B.
56. Pelecanidæ........	*Phalacracorax carbo*	B.

Class REPTILIA.

No list sent in.

Class PISCES.

No typical series sent in; but Jonathan Couch, Esq. has furnished the following list of British Fish, which he considers may be useful to local Museums, as they can all be procured at small expense.

Blue Shark, *Carcharias glaucus*, or else the Toper, *Galerius vulgaris.*

Picked Dog, as an example of such as have spines on the back.

Nursehound, *Scyllium Catulus*, as one of the Ground Sharks.

Porbeagle, as one of the class that bears a ridge on the side near the tail.

The Common Skate, or the Thornback; and for examples of variations in the teeth, as being conspicuous objects of distinction among Sharks and Rays, the jaws should be exhibited separately. A complete series of them from all the British species of these two subfamilies would be very instructive, and might be easily obtained.

As aberrant genera, the Monk, Torpedo, and Sting-ray.

The Perch, or Bass.

Smooth Serranus, for those with a single dorsal fin and serrated gill-covers.

The greater Weaver.

Surmullet.

Common Gurnard; the mailed Gurnard for an aberrant type.

Common Cottus and armed Bullhead.

Of Sticklebacks; the fifteen-spined should be preferred, as being easy to be procured, and more easily examined than the smaller species.

The Common Sea Bream. Ray's Bream.

Common Mackerel, or else the Tunny. Scad.

Doree.

Red Band-fish.

Grey Mullet.

Common Blenny. Wolf-fish. Gattorugine. Butter-fish.

Rock Goby.

Either of the Callionymi, but *C. Lyra* in preference.

Angler.

Ballan Wrass, and as an example of the Wrass tribe with serrated gill-covers, the Corkwing. The Cook also would be desirable, as displaying beauty of colouring; which by art may be preserved from fading.

I pass over the freshwater fishes, to name the Gar-fish, and its congener, the Skopster.

Flying-fish, and in preference the *Exocœtus exiliens*, as being perhaps the only species ever yet found in our seas.

Herring or Pilchard.

Cod-fish.

Coal-fish.

Hake, Rockling, for aberrant genera.

The Plaice, or Flounder, looking to the right.

Brill, looking to the left. *Rhombus hirtus*, as possessing peculiarities of form, roughness of skin, and remarkable position of the dorsal fin.

The Sole, showing an elongated form.

The Lump-fish, and any of the smaller species in spirit.

The Remora, as displaying a variation in the mode of forming adhesion (which may be illustrated by another method of doing the same thing, although with a very different object, in the Sea Lamprey).

The Common Eel, or Conger.

The larger Launce.

Syngnathus acus, for the subfamily with tail and pectoral fin, bearing its young in a pouch; and *S. Ophidion*, not having these fins, and bearing its ova adhering to the belly.

Sun-fish.

MOLLUSCA.

The following list, from Cephalopoda to Tunicata, has been supplied by S. P. Woodward, Esq.

Classis I. CEPHALOPODA.

Best example, SPIRULA.

Ordo I. DIBRANCHIATA.

(Onychoteuthis or Ommastrephes.)

Fam. 1.	Argonautidæ ..	*Argonauta argo.*	
2.	Octopodidæ....	*Octopus vulgaris*......	B.
3.	Teuthidæ	*Loligo vulgaris*	B.
4.	Belemnitidæ ..	*Belemnites Oweni*	B.
5.	Sepiadæ	*Sepia officinalis*	B.
6.	Spirulidæ	*Spirula Peronii*	B.

Ordo II. TETRABRANCHIATA. (Orthoceras.)

Fam. 1.	Nautilidæ	*Nautilus pompilius.*	
2.	Orthoceratidæ..	*Actinoceras giganteum*	B.
3.	Ammonitidæ ..	*Ammonites Jason*	B.

Classis II. GASTEROPODA.

(*Turbo marmoratus.*)

Ordo I. NUCLEOBRANCHIATA. (Carinaria.)

Fam. 1.	Firolidæ	*Firola coronata.*
2.	Atlantidæ	*Atlanta Peronii.*

Ordo II. PROSOBRANCHIATA. (Buccinum and Turbo.)

Fam.	1. Strombidæ	*Strombus giganteus.*	
	2. Buccinidæ	*Buccinum undatum*	B.
	3. Conidæ	*Conus marmoreus.*	
	4. Volutidæ	*Voluta musica.*	
	5. Cypræidæ	*Cypræa tigris.*	
	6. Naticidæ	*Natica millepunctata.*	
	7. Cancellariadæ..	*Trichotropis borealis* ..	B.
	8. Pyramidellidæ..	*Pyramidella dolabrata.*	
	9. Calyptræidæ ..	*Calyptræa sinensis*	B.
	10. Ianthinidæ	*Ianthina exigua*	B.
	11. Turritellidæ....	*Turritella communis* ..	B.
	12. Cerithiadæ	*Cerithium vulgatum.*	
	13. Melaniadæ	*Melania inquinata.*	
	14. Litorinidæ	*Litorina litorea*	B.
	15. Paludinidæ	*Paludina vivipara*	B.
	16. Turbinidæ	*Trochus Zizyphinus* ..	B.
	17. Haliotidæ	*Haliotis tuberculata* ..	B.
	18. Fissurellidæ ..	*Fissurella reticulata* ..	B.
	19. Neritidæ	*Nerita peloronta.*	
		(*Neritina fluviatilis* ..	B.)
	20. Patellidæ......	*Patella vulgata*	B.
	21. Dentaliadæ	*Dentalium Tarentinum*	B.
	22. Chitonidæ	*Chiton lævis*	B.

Ordo III. PULMONIFERA. (a great *Bulimus* or *Achatina.*)

§§ 1. Inoperculata.

Fam.	1. Helicidæ......	*Helix pomatia*	B.
	2. Limacidæ	*Limax antiquorum*	B.
	3. Oncidiadæ	*Oncidium celticum*	B.
	4. Limneidæ	*Limnæa stagnalis*	B.
	5. Auriculidæ	*Conovulus denticulatus*	B.

§§ 2. Operculata.

	6. Cyclostomidæ..	*Cyclostoma elegans*....	B.
	7. Aciculidæ	*Acicula fusca*	B.

Ordo IV. OPISTHOBRANCHIATA. (Aplysia.)

§§ 1. Tectibranchiata.

Fam.	1. Tornatellidæ ..	*Tornatella fasciata*....	B.
	2. Bullidæ	*Bulla hydatis*	B.

§§ 2. Inferobranchiata.

Fam.	3. Aplysiadæ	*Aplysia hybrida*	B.
	4. Pleurobranchidæ	*Pleu. membranaceus* ..	B.
	5. Phyllidiadæ....	*Diphyllidia lineata*....	B.

§§ 3. Nudibranchiata.

Fam.	6. Doridæ	*Doris tuberculata*......	B.
	7. Tritoniadæ	*Tritonia Hombergi*....	B.
	8. Æolidæ	*Æolis papillosa*	B.
	9. Phyllirhoidæ ..	*Phyllirhoa bucephala.*	
	10. Elysiadæ......	*Elysia viridis*	B.

Classis III. PTEROPODA.

Ordo 5. Aporobranchiata. (Cleodora.)

Fam. 1. Hyaleidæ	*Hyalea telemus.*	
2. Limacinidæ....	*Limacina arctica.*	
3. Cliidæ	*Clio borealis.*	

Classis IV. ACEPHALA. (Cytherea, Chione.)

Classis V. CONCHIFERA.

Ordo I. Lamellibranchiata.

§§ 1. Asiphonida.

Fam. 1. Pectinidæ	*Pecten maximus*	B.
2. Ostreidæ	*Ostrea edulis*	B.
3. Aviculidæ	*Avicula margaritifera.*	
4. Mytilidæ	*Mytilus edulis*........	B.
5. Arcadæ	*Arca Noæ.*	
6. Nuculidæ......	*Nucula nucleus*	B.
7. Trigoniadæ	*Trigonia clavellata*....	B.
8. Unionidæ......	*Unio pictorum*	B.

§§ 2. Integropallialia.

9. Chamidæ......	*Chama macrophylla.*	
10. Hippuritidæ ..	(*Caprotina semistriata.*)	
11. Tridacnidæ	*Tridacna gigas.*	
12. Cardiadæ......	*Cardium* (*echinatum*)..	B.
13. Lucinidæ......	*Lucina borealis*	B.
14. Astartidæ	*Astarte sulcata*	B.
15. Cyprinidæ	*Cyprina Islandica*	B.

§§ 3. Sinupallialia.

16. Veneridæ	*Cytherea chione*	B.
17. Mactridæ	*Mactra stultorum*	B.
18. Tellinidæ	*Tellina* (*crassa*)	B.
19. Solenidæ......	*Solen ensis*	B.
20. Myacidæ......	*Mya arenaria*	B.
21. Anatinidæ	(*Thracia pubescens*) ..	B.
22. Gastrochænidæ	*Gastrochæna modiolina*	B.
23. Pholadidæ	*Pholas dactylus*	B.

Classis VI. BRACHIOPODA.

Ordo II. Palliobranchiata.

Fam. 1. Terebratulidæ..	*Terebratula caput-serpentis*	B.
2. Spiriferidæ	*Spirifera striata*......	B.
3. Rhynchonellidæ	*Rhynchonella psittacea*	B.
4. Orthidæ	*Orthis resupinata*	B.
5. Productidæ....	*Producta gigantea*	B.
6. Craniadæ	*Crania anomala*	B.
7. Discinidæ	*Discina lamellosa.*	
8. Lingulidæ	*Lingula anatina.*	

Classis VII. TUNICATA.

Ordo III. Heterobranchiata, *Bl.*

1. Ascidiadæ	*Ascidium intestinale* ..	B.
2. Clavellinidæ ..	*Clavellina lepadiformis*	B.
3. Botryllidæ	*Botryllus violaceus*	B.
4. Pyrosomidæ ..	*Pyrosoma atlanticum.*	
5. Salpidæ	*Salpa democratica.*	

Mollusca (continued).—G. Busk, Esq. has furnished the following list for the lower groups of Mollusca.

Classis POLYZOA.

Ordo I. P. INFUNDIBULATA.

Subordo I. Cheilostomata. (Celleporina.)

§ A. *Polyzoarium articulated.*

§§ a. *Uniserial.*

Fam. 1. Catenicellidæ	*Catenicella hastata.*	

§§ b. *Bi-multiserial.*

Fam. 2. Salicornariadæ	*Salicornaria farciminoides*..	B.
3. Cellulariadæ	*Cellularia Peachii*	B.

§ B. *Polyzoarium not articulated, but continuous throughout.*

§§ a. *Uniserial.*

Fam. 4. Scrupariadæ	*Scruparia chelata*	B.

§§ b. *Bi-multiserial.*

Fam. 5. Farciminariadæ ..	*Farciminaria aculeata.*	
6. Gemellariadæ	*Gemellaria loricata*	B.
7. Callereadæ	*Caberea Hookeri*..........	B.
8. Bicellariadæ	*Bicellaria ciliata*	B.
9. Flustradæ	*Flustra foliacea*	B.
10. Membraniporadæ ..	*Membranipora membranacea*	B.
	Lepralia auriculata	B.
11. Celleporadæ	*Cellepora pumicosa*	B.
12. Escharadæ........	*Eschara foliacea*..........	B.
13. Vinculadæ........	*Vincularia ornata.*	
14. Selenariadæ	*Cupularia Lowei.*	

Subordo II. Cyclostomata. (Tubuliporina.)

§ 1. *Erect, not adnate.*

§§ a. *Articulated, or having the polyzoary divided into internodes united by flexible joints.*

Fam. 1. Crisiadæ	*Crisia eburnea*	B.

§§ b. *Polyzoary continuous throughout.*

Fam. 2. Idmoneadæ........	*Idmonea atlantica*	B.
	Pustulipora deflexa	B.

§ 2. *Decumbent, more or less adnate.*

Fam. 3. Alectoadæ	*Alecto granulata*	B.
4. Tubuliporadæ	*Tubulipora serpens*	B.
5. Discoporadæ	*Discopora patina*	B.

Subordo III. Ctenostomata. (Vesicularina.)

§ 1. *Corneous; the polyzoary composed of a horny substance, sometimes containing earthy matter.*

Fam. 1. Vesiculariadæ......	*Serialaria lendigera*	B.
2. Farelladæ	*Bowerbankia imbricata*	B.

§ 2. *Carnose; the polyzoary composed of a fleshy or semigelatinous substance.*

Fam. 3. Alcyoniadæ........	*Alcyonium gelatinosum*	B.

Subordo IV. Pedicellinea.

Fam. 1. Pedicellinidæ	*Pedicellina echinata*	B.

Ordo II. P. HIPPOCREPIA.

§ 1. *Lophophore bilateral; mouth furnished with a valve.*

§§ a. *Free, locomotive.*

Fam. 1. Cristatellidæ	*Cristatella mucedo*	B.

§§ b. *Rooted.*

Fam. 2. Plumatellidæ	*Alcyonella fungosa*	B.

§ 2. *Lophophore orbicular, mouth destitute of a valve.*

Fam. Paludicellidæ	*Paludicella Ehrenbergi*	B.

Arachnida.—R. H. Meade, Esq., has forwarded the list for this group.

Ordo I. ARANEIDEA.

Tribus Octonoculina.

Epeira diadema (best type for the whole order).

Fam. I. Mygalidæ (Latebricolæ)	*Mygale avicularia.*	
II. Lycosidæ (Cursores) ..	*Lycosa tarantula.*	
	(*Lycosa saccata*)	B.
III. Salticidæ	*Salticus scenicus*	B.
IV. Thomisidæ (Laterigradæ)	*Thomisus cristatus*	B.
V. Drassidæ (Niditelæ) ..	*Clubiona holosericea*	B.
VI. Agelenidæ (Tassitelæ)	*Agelena labyrinthica*	B.
VII. Theridiidæ	*Theridion nervosum*	B.
VIII. Linyphiidæ (Retitelæ)	*Linyphia montana*	B.
IX. Epeiridæ (Orbitelæ) ..	*Epeira diadema*	B.

Tribus Senoculina.

Fam. X. Dysderidæ (Tubicolæ)	*Dysdera erythrina*	B.

Ordo II. PHRYNEIDEA.

Phrynus lunatus.

Ordo III. SCORPIONIDEA.

Fam. I. Scorpionidæ	*Scorpio Europæus.*
II. Buthides	*Buthus afer.*
III. Centrurides	*Centrurus gallineus.*
IV. Androctonides	*Androctonus bicolor.*

Subordo I. THELYPHONIDÆ.

Thelyphonus caudatus.

Subordo II. PSEUDO-SCORPIONIDÆ.

Chelifer cancroides .... B.

Ordo IV. PHALANGIDEA.

Fam. I. Solpugiidæ	*Galeodes araneoides.*	
II. Phalangiidæ	*Phalangium parietinum*	B.
III. Troguliidæ	*Trogulus nepæformis*	B.?
IV. Gonyleptiidæ	*Gonyleptes horridus.*	
V. Sironidæ	*Siro rubens*	B.

Ordo V. ACARIDEA.

Fam. I. Trombidiadæ	*Trombidium holosericeum* ..	B.
II. Gammasiidæ	*Gammasus coleoptratorum* ..	B.
III. Acariidæ	*Acarus domesticus*	B.
IV. Ixodiidæ	*Ixodes Ricinus*	B.
V. Cheyletiidæ	*Sarcoptes Scabiei*	B.
VI. Hydrachnadæ	*Limnochares holosericea*	B.

CRUSTACEA.

The following list of the Podophthalma is furnished by T. Bell, Esq., President of the Linnean Society.

Subclassis PODOPHTHALMA.

Ordo DECAPODA.

Subordo BRACHYURA.

Fam. Leptopodiadæ	*Leptopodia sagittaria.*	
	(*Stenorynchus Phalangium*)	B.
Maiadæ	*Maia Squinado*	B.
Parthenopidæ	*Parthenope horrida.*	
Canceridæ	*Eurynome aspera*	B.
Subfam. Cryptopodia (Æthrina)	*Æthra scruposa.*	
Arcuata (Cancerina) ..	*Cancer Pagurus*	B.
Quadrilatera (Eriphina)	*Eriphia spinifrons.*	
Fam. Portunidæ	*Portunus puber*	B.
Thelphusidæ	*Thelphusa fluviatilis.*	
Gecarcinidæ	*Gecarcinus ruricola.*	
Pinnotheridæ	*Pinnotheres Pisum*	B.
Ocypodidæ	*Ocypode Ippeus.*	
	(*Gelasimus vocans*).	
Gonoplacidæ	*Gonoplax angulata*	B.
Grapsidæ	*Grapsus pictus.*	
	(*Nautilograpsus minutus*)	B.
Leucosiadæ	*Leucosia Urania.*	
	(Aberrans.) *Ebalia Pennantii* ..	B.
Calappadæ	*Calappa granulata.*	
	(Aberrans.) *Matuta Victor.*	
Corystidæ	*Corystes Cassivelaunus* ..	B.
Dorippidæ	*Dorippe quadridentata.*	

Subordo ANOMOURA.

Fam.	Dromiadæ	*Dromia vulgaris*	B.
	Homoladæ	*Homola spinifrons.*	
		Lithodes arctica	B.
	Raninadæ	*Ranina dentata.*	
	Hippadæ	*Remipes testudinarius.*	
	Paguridæ............	*Pagurus Bernhardus*	B.
		(Aberrans.) *Birgus Latro.*	
Subfam.	Porcellanidæ	*Porcellana violacea.*	
	Porcellanina	*Porcellana platycheles*	B.
	Galatheina	*Galathea strigosa*	B.

Subordo MACROURA.

Fam.	Scyllaridæ	*Scyllarus arctus.*	
	Palinuridæ	*Palinurus vulgaris*	B.
	Thalassinidæ	*Thalassina scorpionides.*	
		Gebia Deltura	B.
	Astacidæ	*Astacus fluviatilis*........	B.
	Crangonidæ..........	*Crangon borealis.*	
		Crangon vulgaris........	B.
	Alpheidæ............	*Alpheus bidens.*	
		Alpheus ruber	B.
	Palemonidæ..........	*Palemon Carcinus.*	
		Palemon serratus	B.
	Penæidæ	*Penæus Caramote.*	
		Penæus trisulcatus	B.
	Cumadæ	*Cuma trispinosa*	B.

Ordo STOMOPODA.

Fam.	Mysidæ	*Mysis Chamæleon*........	B.
	Leuciferidæ..........	*Leucifer Typus.*	
	Phyllosomatidæ	*Phyllosoma laticorne.*	
	Erichthidæ	*Erichthus vitreus.*	
	Squilladæ............	*Squilla Mantis*..........	B.

Dr. Baird furnishes the following list for Entomostraca.

Divisio ENTOMOSTRACA.

Legio I. BRANCHIOPODA.

Ordo I. PHYLLOPODA.

Apus Cancriformis .... B.
Chirocephalus (Branchipus) diaphanus .... B.

Legio II. LOPHYROPODA.

Ordo I. OSTRACODA.

Cypris vidua, *Candona reptans* } fresh water................ B.
Cythere reniformis, sea water .... B.

Ordo II. CLADOCERA.

Daphnia quadricornis .... B.
Chydorus (*Lynceus*) *sphæricus* .... B.

Ordo III. COPEPODA.

Cyclops vulgaris .... B.

Legio III. PŒCILOPODA.

Ordo I. SIPHONOSTOMA.

Argulus foliaceus (on Stickleback).............. B.
Caligus Mulleri (on Cod) .... B.
Lepeophtheirus (*Caligus*) *Stromii* (on Salmon).... B.

Ordo II. LERNÆIDÆ.

Chondracanthus lophii. .... B.
Lernæa branchialis .... B.

The following list for the Cirripedia is communicated by C. Darwin, Esq.

Subclassis CIRRIPEDIA.

Ordo I. THORACICA.

Pollicipes mitella (best type for the order).

Fam. 1. Balanidæ (sessile Cirripeds).		
Subfam. 1. Balaninæ	*Balanus tintinnabulum.*	
	—— *porcatus*	B.
2. Chthamalinæ	*Chthamalus stellatus* ..	B.
	Catophragmus polymerus (as connecting Balanidæ with Lepadidæ).	
Fam. 2. Verrucidæ	*Verruca stromia*	B
3. Lepadidæ (pedunculated Cirripeds)	*Lepas anatifera*	B

Ordo II. ABDOMINALIA.

Cryptophialus minutus.

Ordo III. APODA.

Proteolepas bivincta.

RADIATA.

Among these, G. Busk, Esq. has furnished the following list for the class Anthozoa.

Classis ANTHOZOA.

Subclassis I. A. HYDROIDA.

Ordo I. TUBULARINA.

Fam. 1. Corynidæ	*Coryne pusilla*...........	B.
2. Tubulariadæ	*Tubularia indivisa*	B.

Ordo II. SERTULARINA.

Fam. 3. Sertulariadæ	*Sertularia abietina*	B.
	Plumularia cristata	B.
4. Campanulariadæ	*Laomedea dichotoma*	B.

Ordo III. HYDRINA.

Fam. 5. Hydroidæ	*Hydra viridis*, or *vulgaris*.	B.

Subclassis II. A. ASTEROIDA.

Fam. 1. Pennatulidæ	*Pennatula phosphorea*	B.
2. Gorgoniadæ	*Gorgonia verrucosa*	B.
3. Alcyonidæ	*Alcyonium digitatum*	B.
4. Antipathidæ	*Antipathes myriophylla*	B.

Subclassis III. A. HELIANTHOIDA (Zoantharia).

Ordo I. MALACODERMATA.

§ 1. *Polypes associated by a common base.*

Fam. 1. Zoanthidæ	*Zoanthus Couchii*	B.

§ 2. *Polypes separate.*

Fam. 2. Actiniadæ	*Actinia mesembryanthemum*	B.
3. Lucernariadæ	*Lucernaria auricula.*	

Ordo II. SCLERENCHYMATOSA. (Corals.)

Subordo I. Aporosa.

Fam. 1. Turbinolidæ.		
Tribus 1. Cyathininæ	*Cyathina cyathus.*	
2. Turbinolinæ	*Turbinolia borealis.*	
Fam. 2. Oculinidæ	*Oculina virginea.*	
3. Astreidæ.		
Tribus 1. Eusmilinæ.		
§ 1. E. propriæ	*Eusmilia fastigiata.*	
2. E. confluentes	*Ctenophyllia mæandrites.*	
3. E. aggregatæ	*Stylina echinulata.*	
4. E. immersæ	*Sarcinula organum.*	
Tribus 2. Astreinæ.		
§ 1. Astreinæ hirtæ	*Caryophyllia Smithii*	B.
2. A. confluentes	*Meandrina filograna.*	
3. A. dendroidæ	*Cladocora cæspitosa.*	
4. A. aggregatæ	*Astrea cavernosa.*	
5. A. reptantes	*Angia rubeola.*	
Fam. 4. Fungidæ.		
Tribus 1. Cyclolitinæ	*Cyclolites elliptica.*	
2. Funginæ	*Anabacia orbulites.*	
3. Lophoserinæ	*Agaricia undata.*	

Subordo II. Z. PERFORATA seu POROSA.

Fam. 5. Eupsammidæ	*Eupsammia trochiformis.*	
6. Madreporidæ.		
Tribus 1. Madreporinæ	*Madrepora muricata.*	
2. Explanarinæ	*Explanaria crater.*	
Fam. 7. Poritidæ.		
Tribus 1. Poritinæ	*Porites conglomerata.*	
2. Montiporinæ	*Alveopora rubra.*	

Subordo III. Z. TABULATA.

Fam. 8. Milleporidæ	*Millepora alcicornis.*
9. Favositidæ.	
Tribus 1. Favositinæ	*Favosites Gothlandica.*
2. Chætetinæ........	*Chætetes radians.*
3. Halysitinæ	*Halysites escharoides.*
4. Pocilloporinæ	*Pocillopora acuta.*
Fam. 10. Seriatoporidæ	*Seriatopora subulata.*
11. Thecidæ	*Thecia Swinderniana.*

Subordo IV. Z. RUGOSA.

Fam. 12. Stauridæ	*Stauria astreiformis.*
13. Cyathaxonidæ	*Cyathaxonia cornu* (fossil).
14. Cyathophyllidæ	
Tribus 1. Zaphrentinæ......	*Zaphrentis patula* (fossil).
2. Cyathophyllinæ ..	*Cyathophyllum helianthoides* (fossil).
3. Lithodendroninæ ..	*Lithodendron irregulare* (fossil).
Fam. 15. Cystiphyllidæ	*Cystiphyllum Siluriense* (fossil).

VEGETABLE KINGDOM.

Dried plants from the Herbarium cannot be advantageously displayed in glass cases. The following method may be adopted for the Typical Epitome:—a few wax models of flowers, with figures of such parts as require to be magnified; but especially entire fruits, with dissections exposing the seed and embryo. As a general plan for fruits and seeds, there should be exhibited,—

1. Entire fruit, dried or (where succulent) modelled in wax.
2. Section of the pericarp to expose the seed in position.
3. Entire seed.
4. Section of seed to expose the embryo.
5. Embryo. When minute, it may be preserved as a microscopic object, and accompanied by a figure of it magnified.

These preparations should be protected against the attacks of insects, by being steeped in a solution of corrosive sublimate.

In addition to the illustrations displayed in the Epitome, dried specimens and figures may be arranged in a "Typical Herbarium."

If the following plan of drawing up a joint list of objects for the "Typical Herbarium," and the Epitome to be exposed under glass, should be approved, it will be continued in a Second Report. J. S. HENSLOW.

(a longitudinal and ⌒ a transverse section.

Typical Herbarium.	Specimens displayed under glass.			
	Flower.	F, fruit. P, pericarp.	S. seed.	E. embryo.
Classis I. DICOTYLEDONES.				
Subclassis 1. THALAMIFLORÆ.				
Ordo. RANUNCULACEÆ.				
Tribus. Clematideæ	*v.* T. Herb.			
Clematis vitalba.... E.B. 612.. B.	..	F, (P		
—— cirrhosa...... B.M. 1070.				
—— (Atragene) verticillaris .... B.M. 887				
Tribus. Anemoneæ.				
Anemone pulsatilla.. E.B. 51.. B.	..	F, (P		
—— narcissiflora .. B.M. 1120				
—— hepatica...... B.M. 10				
Tribus. Ranunculeæ.				
Ranunculus aquatilis E.B. 101.. B.	..	F		
—— bulbosus...... E.B. 517.. B.	Figure	F, (P		
—— arvensis ...... E.B. 135.. B.		F		
—— ficaria........ E.B. 584.. B.				
Tribus. Helleboreæ.				
Helleborus niger .. B.M. 8..	..	F, (P		
—— fœtidus ...... E.B. 613.. B.				
Nigella damascena B.M. 22..	..	F, ⌒ P		
Aquilegia vulgaris.. E.B. 297.. B.				
Tribus. Pæonieæ.				
Pæonia officinalis .. B.M. 1784.. B.	..	F, (P	S, (S	E + fig.
—— corallina .... E.B. 1515 .. B.				
Tribus. Actæeæ.				
Actæa spicata...... E.B. 918.. B.	..	F, { dry & wax		
Ordo. DILLENIACEÆ	*v.* T. Herb.			
Tribus. Delimeæ.				
Delima hebecarpa. Dell.Ic. 72				
Tribus. Dilleneæ.				
Dillenia speciosa. Sm.Ex.Bot. 2				
Ordo. MAGNOLIACEÆ.	*v.* T. Herb.			
Tribus. Ilicieæ.				
Ilicium floridanum B.M. 439				
Tribus. Magnolieæ.				
Magnolia grandiflora B.R. 518				

MINERAL KINGDOM.

For educational uses, the mineralogical and geological portions of the Typical Epitome may be preluded by a few illustrations of some of the important properties of minerals. The following notice of such illustrations as have been introduced into the Ipswich Museum may suggest others.

No. 1. As many of the elements as can be exposed under glass.
„ 2. Scale of temperatures at which some of the elements appear solid, liquid, and gaseous.
„ 3. A compound substance, of given weight, exhibited with the relative weights of the ingredients of which it is composed:—
Ex. gr. Cinnabar (HgS); with sulphur and mercury.
„ A grain of water (HO); with relative bulks of oxygen and hydrogen.
„ Gypsum (CaO,SO_3+2HO); with lime, sulphuric acid, and water.
„ 4. Malleability, extreme in gold.
„ 5. Ductility, extreme in platina.
„ 6. Specific gravity illustrated by a drawing.
„ 7. Hardness, tested by nine simple minerals adopted in Mohs's scale, each scratched by the one which succeeds, except the last, which is scratched only by diamond.
1. Talc. 2. Rock-salt. 3. Calcite. 4. Fluor. 5. Apatite. 6. Felspar. 7. Quartz. 8. Topaz. 9. Corundum.
„ 8. Magnetism with polarity, exposed by a compass-needle deflected by a piece of magnetite.
„ 9. Crystallization produced from four predisposing influences:—
1. *Solution,*—alum; blue copperas; and ferrocyanate of potash.
2. *Fusion,*—bismuth; sulphur; and slag of an iron furnace.
3. *Sublimation,*—naphthaline; camphor; and biniodide of mercury.
4. *Precipitation,*—lead; tin; and silver,
„ 10. Cleavage, very distinct in,—
1. *one* direction, in mica;
2. *three* directions, in calcite;
3. *four* directions, in fluor.
„ 11. Models to illustrate the six systems of crystals; severally represented by a letter and a colour as follows: —

Cubic system........	O	Red.
Pyramidal..........	Q	Orange.
Rhombohedral	R	Yellow.
Prismatic	P	Green.
Oblique............	S	Blue.
Anorthic	T	Purple.

„ 12. Pseudomorphism in Haytorite, *i.e.* quartz in the form of datholite.
„ 13. Nodular arrangement,
1. from igneous action,—in devitrified glass; and in Corsican granite;
2. from aqueous agency,—in iron pyrites;
3. metamorphic rearrangement,—in a mass of limestone (*nodular disintegration*).
„ 14. Stalactitic and stalagmitic concretions,—in calcite.
„ 15. Polarization of light.
„ 16. Double refraction,—in calcite.

Mineralogy.

An Epitome of this science has been formed by placing one small specimen of every procurable species noticed in Brooke's 'Mineralogy,' on stout cardboard of a given size. A letter indicating the system, and printed on the appropriate colour, is pasted on the cardboard to the left above the specimen,

and its chemical composition is introduced to the right; the name is addeo below. The whole does not occupy 5 feet by 2, although blank spaces are left for the species not yet obtained.

Geology.

As no returns have yet been received from geologists, perhaps we may improve upon the suggestions offered in the Circular, by asking, *in addition*, for lists of such genera as first occur in each formation, and also of such as disappear in each. It will be serviceable to those who cater for Museums, to receive references to localities whence the typical rock specimens may be most readily obtained.

P.S. Since the above was in type, Professor Huxley has suggested the following arrangement as an approximation to a scheme which shall exhibit the equivalent classes and sub-classes of the animal kingdom. The brackets imply, that in his opinion there is good reason for fusing into one group the sub-classes thus united, and giving a new name to the whole, to be regarded as equivalent to the other sub-classes. Where (H?) is added to a group, he considers it very doubtful whether such is really an equivalent to the other sub-classes. An (R) is placed after those groups which were united by Cuvier under Radiata. Professor Huxley proposes at the next meeting of the Association to read a statement of his reasons for proposing the above classification, and to discuss any points in it which may appear doubtful to other naturalists.

I. Vertebrata.

(*Abranchiata.*)
Mammalia.
Aves.
Reptilia.
(*Branchiata.*)
Amphibia (H?).
Pisces.

II. Mollusca.

(§ A.)

Cephalopoda.

{ Heteropoda.
Gasteropoda dioecia. }

{ Pulmonata.
Pteropoda. }

Gasteropoda monoecia.

Lamellibranchiata.

(§ B. *Molluscoida.*)

{ Brachiopoda.
Polyzoa (R). }

Ascidioida.

III. Annulosa.

(§ A.)

Insecta. Arachnida.
Myriapoda. Crustacea.

(§ B. *Annuloida.*)

Annelida. Scoleidæ (H?).
Echinodermata.
{ Trematoda (R).
Tæniadæ (R).
Turbellaria (R). }
Rotifera (R. H?). Nematoidea (R. H?).

IV. Cœlenterata.

Hydrozoa (R). Actinozoa (R).

V. Protozoa.

{ Infusoria (R).
Noctilucidæ. }
Spongiadæ (R).
Foraminifera (R).
Gregarinidæ (R).
Thalassicallidæ (H?).

An Account of the Self-registering Anemometer and Rain-gauge erected at the Liverpool Observatory in the Autumn of 1851, *with a Summary of the Records for the years* 1852, 1853, 1854, *and* 1855. *By* A. Follett Osler, *F.R.S.*

It was at the Meeting held in Liverpool in 1837, that my self-registering Anemometer and Rain-gauge were first introduced to the notice of the British Association. Never having previously seen any instruments designed to accomplish similar purposes, I was at the outset much at fault, especially with regard to the Anemometer, and soon became sensible that to construct one that would record light winds with any degree of accuracy, and at the same time effect the registration of storms and hurricanes, would necessarily involve many difficulties. Subsequent experience has enabled me to overcome most of these, and I believe that the instruments now under the able superintendence of Mr. Hartnup, at the Liverpool Observatory, of which I subjoin a brief description, have for these four years past registered an accurate and complete series of results.

The direction of the wind is obtained by means of a wheel-fan, similar to that at the back of a windmill; this preserves a steady action and is very free from oscillation. Its motion is connected with the recording portion of the instrument, by means of a tube carrying at the lower end a large screw or spiral groove *, to which the direction pencil is attached; the motion given by this means causing a pencil to trace the direction of the wind on a sheet of paper stretched on a vertical cylinder, which is moved at a uniform rate by means of a clock. The paper is engraved with perpendicular lines to show the time, and with horizontal lines to indicate the direction.

The force of the wind is ascertained by means of a circular plate having an area of four square feet, which is kept by the vane at right angles to the current of the wind. This plate is suspended by four light springs, immediately behind which are four strong ones, the whole being so arranged that the light springs are in action in light winds, but as the force increases the pressure is gradually received on the strong ones. To this pressure-plate is attached a wire which communicates with a recording pencil below, that marks off the force of the wind in pounds avoirdupois per square foot on the margin of the paper on which the direction is recorded.

For the method employed for ascertaining the amount of horizontal motion of the air, I am indebted to Dr. Robinson, who first introduced that beautiful and simple arrangement of the revolving hemispherical cups. These cups revolve in a horizontal plane, the difference in resistance between the convex and concave surfaces securing their constant revolution in one direction at a velocity of one-third of that of the air†. Dr. Robinson has fully explained the laws that regulate their motion in a paper to the Royal Irish Academy (vol. xxii. part 3). The plan for registration, however,

* In the first instrument the paper was placed horizontally, and the motion conveyed to the direction pencil by means of a rack and pinion; but finding a vertical position on several accounts more convenient, I made use of the screw movement described above, which had been previously suggested in a conversation with the late Mr. Henry Knight, of Birmingham.

† In the first instrument which I erected at Birmingham, the velocity of the air was obtained by means of a light wheel three feet in diameter, placed horizontally, having fans resembling those on a water-wheel, the greater portion of the wheel being screened by a cover with a vane attached to it, so that only a few of the fans were exposed to the action of the wind. The number of revolutions was recorded on the same paper on which the other registers were taken, by communicating their motion, reduced by screw movements, to a spiral incline, which propelled a pencil at right angles to the direction in which the paper was moved by the clock. I found, however, that the high velocity at which it revolved interfered so much with its durability and accuracy, that after a few months I discontinued the use of it. I have

which I have employed, consists in communicating the motion of the hemispheres reduced by screw movements* to a vertical cylinder covered with a plain sheet of paper; a pair of pointed hammers strike a dot on each margin of the paper on the completion of every hour; but when gales of wind or storms occur, and the paper moves more rapidly, the spaces between the hourly dots can be subdivided by throwing into gear another pair of hammers, whereby the half-hours, quarter-hours, or even intervals of five minutes, may be indicated if required. The pencil that traces the horizontal motion is connected with the direction register, while the lines that indicate the cardinal points are at the same time ruled off by a series of narrow notched rollers. The direction, horizontal motion, and time, are by these means simultaneously recorded.

The rain-funnel exposes an area of four hundred square inches, and the water passes into a glass vessel below, suspended on a bent lever balance, to which a pencil is attached, to record the quantity of rain that falls, on the margin of the same paper as that on which the wind is registered. The line traced will thus show the exact time at which each fall of rain commenced and ended, while its curve indicates the rate at which it fell. To enable the quantity of rain to be read with accuracy, the scale is enlarged, so that one quarter of an inch of rain is represented by a space of two inches on the paper; whenever a quarter of an inch of rain has fallen, the glass vessel discharges its contents, and the pencil returns to zero.

The following Tables, prepared by Mr. Hartnup, are abstracts arranged from the tabulated registers of the Anemometer and Rain-gauge at the Liverpool Observatory, during the years 1852, 1853, 1854, and 1855. The very exact and punctual manner in which the records have been kept, as well as the great amount of information tabulated, has given a peculiar value to them:—for the benefit of those who may take an interest in carrying on similar observations, copies of the records for one month are printed in full, showing how they are entered daily from the registers given by the instruments. See Tables I. and II.

From the monthly sheets of which Tables I. and II. are specimens, the annual Tables III. and IV. are obtained: in Table III. the results are arranged according to the points of the compass, and in Table IV. according to the hours of the day. It is unnecessary to enter on a detailed description of these, as the heading of each table and column affords sufficient explanation.

since found that this principle had been previously applied, though, I believe, not to registration as regards time. Still, feeling the importance of obtaining the velocity as well as the force of the wind, I some years afterwards adopted the following method. A series of fans was fixed on a light vertical wheel three feet in diameter, which was kept opposed to the current of the air in the direction of the axis by means of the vane; the fans were set obliquely at an angle which decided the rate at which the wheel would revolve in proportion to the velocity of the air; to this I briefly alluded in a paper which I brought before the British Association at Birmingham (see Report for 1849). The principle is exactly the same as Dr. Whewell's anemometer, the main difference consisting in the fans being placed at a distance from the centre, and at so small an angle to the axis, as to reduce the motion to one-fourth or one-sixth, or any other proportion of the velocity of the air that might be required. Massey's Ship Log is also constructed on this principle. For the purpose of keeping the fans steadily opposed to the current of the air, it is desirable to use a windmill vane, as the continual oscillations of one of the ordinary kind of vanes would seriously interfere with the correct motion of the fans. This was just completed when the revolving hemispherical cups introduced by Dr. Robinson first became known to me: the simplicity of this contrivance pleased me so much, that I at once decided on applying it in preference to my own, though I am inclined to think that in situations where the instrument would be exposed to very violent storms, as in the tropics, the arrangement of fans as just described would probably be found of advantage, both on account of the small resistance offered in passing through the air, and the slow rate at which they may be made to revolve.

* In this instrument, for every inch of paper worked off, the centres of the hemispherical cups travel 12·75 miles, which, according to Dr. Robinson's experiments, is equivalent to 38·25 miles of air passing over the station: the results have been tabulated on this assumption.

The direction of the wind is represented by the following figures:—

N.N.E.	N.E.	E.N.E.	E.	E.S.E.	S.E.	S.S.E.	S.	S.S.W.	S.W.	W.S.W.	W.	W.N.W.	N.W.	N.N.W.	N.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Part 1 (hours 1 A.M. to 12)

1855 July	1 A.M. Miles	Direction	2 Miles	Direction	3 Miles	Direction	4 Miles	Direction	5 Miles	Direction	6 Miles	Direction	7 Miles	Direction	8 Miles	Direction	9 Miles	Direction	10 Miles	Direction	11 Miles	Direction	12 Miles	Direction
1	12	7	11	7	14	8	13	8	13	8	12	8	12	7	14	7	16	7	13	9	14	9	10	12
2	3	4	4	4	4	5	3	6	6	6	6	7	6	7	7	7	3	7	5	14	10	14	11	14
3	8	12	7	13	10	13	9	13	8	13	6	13	10	13	11	13	11	13	11	13	9	13	7	14
4	16	13	11	13	14	13	13	13	13	13	14	13	14	13	11	15	10	15	8	15	11	14	11	13
5	1	15	3	13	2	14	4	14	3	4	3	5	5	7	5	8	5	8	7	8	3	8	6	15
6	9	5	8	5	8	5	11	4	12	6	11	6	11	6	11	6	12	6	13	6	12	7	12	7
7	3	6	3	5	2	12	4	6	4	7	4	7	4	7	5	7	6	7	10	7	10	8	10	8
8	9	6	9	6	10	6	11	6	12	6	10	6	11	7	12	7	10	7	12	7	14	8	12	8
9	8	5	8	5	6	5	9	5	8	5	7	6	7	6	8	6	7	6	11	5	14	6	14	5
10	13	4	11	5	11	4	12	4	12	3	13	3	14	3	12	4	5	5	7	5	10	6	11	7
11	3	3	2	1	7	13	6	14	3	15	4	16	5	16	8	15	13	15	15	14	13	14	11	13
12	2	12	2	12	2	14	2	14	2	15	3	15	2	15	5	15	6	15	6	15	6	15	6	15
13	3	15	3	15	4	14	3	14	7	14	6	14	5	14	4	15	4	16	6	15	10	16	11	15
14	10	8	11	7	9	7	8	8	8	7	5	7	7	9	8	7	8	7	11	7	10	7	10	13
15	5	11	13	12	12	12	13	13	12	13	16	12	20	13	18	13	17	13	15	13	12	13	13	13
16	1	14	3	13	2	13	4	13	3	13	4	13	4	13	1	8	4	9	3	9	6	9	10	13
17	17	13	14	13	16	13	17	13	24	13	26	13	28	13	29	13	29	13	28	13	28	13	29	13
18	21	14	17	14	18	13	19	13	21	13	20	13	19	13	21	13	21	13	20	13	18	13	17	14
19	7	8	9	7	9	8	8	8	8	7	9	7	12	7	11	7	11	7	12	7	14	7	13	7
20	29	13	30	13	32	13	31	13	32	14	32	14	32	13	28	13	26	13	30	13	29	13	32	13
21	8	13	4	12	1	12	3	12	6	7	5	7	5	7	7	7	8	7	10	7	10	7	11	7
22	1	15	2	5	3	14	3	9	1	9	3	9	1	10	3	12	5	9	3	9	3	9	5	9
23	2	15	1	1	1	3	Calm		2	2	2	2	3	1	6	1	7	1	8	1	8	1	6	16
24	2	15	4	14	6	14	10	14	7	13	4	13	8	13	11	13	8	13	5	10	4	10	4	13
25	14	13	10	13	7	13	8	13	10	13	11	13	14	13	13	13	13	13	14	13	14	13	14	13
26	7	7	9	7	7	7	9	6	9	6	9	6	8	6	7	5	7	5	8	5	9	6	9	6
27	5	7	4	7	3	7	6	7	9	7	8	8	6	8	8	8	9	8	11	8	10	8	8	8
28	6	11	6	11	8	11	7	11	6	11	6	11	11	12	13	13	14	13	14	13	15	14	15	14
29	7	14	9	14	10	14	10	14	10	14	8	14	7	14	8	14	12	14	9	14	9	14	9	14
30	2	14	5	14	5	14	4	14	4	12	4	12	3	11	4	11	3	11	4	11	4	11	4	11
31	8	-	9	-	11	-	11	-	9	-	9	-	10	7	9	8	8	8	13	8	8	11	8	10
Sum of Miles.	215		245		254		261		284		280		301		318		318		342		346		349	
Mean of Miles.	7·9		7·9		8·2		8·4		9·1		9·0		9·8		10·2		10·2		11·0		11·1		11·2	

Part 1 (hours 13 to 24) and **Part 2**

1855 July	13 Miles	Direction	14 Miles	Direction	15 Miles	Direction	16 Miles	Direction	17 Miles	Direction	18 Miles	Direction	19 Miles	Direction	20 Miles	Direction	21 Miles	Direction	22 Miles	Direction	23 Miles	Direction	24 Miles	Direction	Daily horizontal motion of the air. Miles.	Mean hourly horizontal motion. Miles.	Extreme pressure on the square foot. Pounds.	Time at which it occurred. Hours	Whole amount of rain in inches. Inches	Time occupied in falling. Hours	Calm hours.
1	15	13	12	13	8	15	5	15	5	15	4	15	3	15	4	16	4	16	4	4	1	3	5	3	227	9·5	2·5	10·9	0·100	2·5	
2	12	14	12	14	14	14	13	14	10	13	8	14	8	14	9	14	7	13	7	13	6	13	7	13	181	7·5	1·5	11·5	·020	2·0	
3	8	15	6	15	9	14	14	13	16	13	15	13	14	13	16	13	16	13	17	13	19	13	17	13	274	11·4	2·7	22·5			
4	11	13	10	14	10	15	9	14	10	14	10	14	7	14	6	14	6	14	11	14	3	14	4	14	246	10·3	2·0	5·2			
5	10	15	13	15	13	15	11	15	8	15	6	16	6	16	4	16	6	2	8	3	8	4	9	5	152	6·3	1·5	13·9			
6	11	7	10	7	8	8	6	8	7	6	6	8	6	7	6	5	7	5	6	-	6	-	3	7	212	8·9	2·0	9·9			
7	10	8	9	8	12	13	11	13	9	14	5	14	3	14	6	14	6	7	11	-	8	-	8	6	163	6·8	2·0	11·6			
8	12	7	16	7	11	8	14	8	12	7	11	6	11	6	11	7	9	-	10	5	12	5	8	5	269	11·1	1·3	13·8			
9	14	5	13	5	13	5	13	5	11	7	10	7	10	6	9	6	12	4	11	4	18	4	13	4	257	10·7	3·0	12·2			
10	7	6	7	5	7	5	8	5	8	5	12	4	10	4	8	4	5	3	4	1	5	4	4	3	216	9·0	2·3	0·2	·395	6·0	
11	13	13	14	13	15	13	12	13	11	13	10	13	10	13	9	13	6	13	3	13	2	12	2	12	197	8·2	2·2	11·7			
12	5	15	4	15	5	15	5	15	4	1	5	14	5	14	4	13	2	13	1	13	1	13	1	15	89	3·7	0·3	17·1	·010	1·0	
13	11	15	8	15	8	15	7	15	5	15	3	15	9	15	12	8	9	8	9	8	7	-	10	-	164	6·8	2·0	19·4	·015	3·0	
14	6	15	6	15	5	14	5	14	4	14	2	14	9	11	15	11	13	9	9	9	8	1	10	11	197	8·2	2·1	18·7	·123	4·5	
15	12	13	10	13	6	15	4	15	4	15	6	14	2	13	2	15	1	15	1	15	1	15	1	15	216	9·0	2·8	6·7	·060	0·5	
16	17	14	13	13	15	13	17	13	18	14	15	14	23	13	17	13	17	13	12	13	13	13	18	13	240	10·0	3·5	20·4	·422	9·0	
17	26	13	25	13	27	13	28	13	29	13	24	13	22	13	20	13	22	13	19	13	22	13	22	14	571	23·9	6·6	16·9			
18	17	14	15	14	13	14	12	14	11	14	10	13	7	13	4	13	2	13	2	13	8	7	8	-	311	14·2	3·6	8·4			
19	13	7	8	9	7	13	10	13	21	14	23	14	24	13	22	13	25	13	28	13	23	13	25	13	352	14·7	5·0	19·9	·160	3·2	
20	29	13	29	13	28	13	28	13	27	13	26	13	23	13	20	13	16	13	18	13	14	13	12	13	633	26·5	6·3	11·2			
21	10	7	10	7	7	13	5	14	3	15	5	15	3	15	1	15	1	15	1	15	1	15	1	15	126	5·2	1·5	11·4			
22	4	15	2	15	2	15	4	15	2	15	2	15	4	15	4	15	5	15	1	15	1	15	1	15	74	3·1	0·2	12·0			
23	7	16	8	16	9	15	9	15	9	15	9	15	8	15	8	15	9	15	6	15	5	15	3	15	136	5·6	0·8	11·3	·213	2·4	1
24	3	15	4	15	6	16	6	1	6	1	7	1	7	1	4	1	5	1	13	12	12	12	15	12	161	7·1	2·0	23·7	·970	13·0	
25	15	13	15	12	18	12	18	12	13	11	12	11	15	12	14	12	10	12	7	-	12	8	11	8	302	12·6	2·3	15·2	1·027	15·7	
26	8	7	9	7	12	7	12	8	11	8	11	8	9	8	9	8	8	8	8	8	9	8	7	-	211	8·8	1·9	14·3	·060	2·0	
27	6	8	6	11	5	11	1	14	4	15	5	15	7	15	5	10	6	1	8	9	7	9	6	[illegible]	153	6·4	2·2	11·2	·290	1·6	
28	14	14	12	14	12	14	15	14	14	14	13	15	11	15	8	15	7	15	7	15	5	15	1	15	213	10·1	2·1	8·5			
29	8	14	8	14	10	14	9	14	10	14	12	14	11	14	9	14	7	15	6	15	5	15	5	14	207	8·6	1·6	7·7			
30	7	10	6	6	6	6	8	7	11	6	12	6	9	11	3	11	7	8	10	8	11	8	8	8	111	6·0	3·5	13·3	·032	2·0	
31	8	9	8	10	6	13	12	13	12	13	8	13	12	13	12	13	9	11	10	11	10	11	11	11	231	9·6	1·9	15·7	0·712	10·0	
Sum of Miles.	349		328		327		321		325		307		308		281		265		271		272		262		7185	298·6	.	...	1·999	81·4	1
Mean of Miles.	11·2		10·6		10·6		10·3		10·5		9·9		9·9		9·7		8·6		8·8		8·5		8·5		231·8	9·6					

Tables I. and II. are copies of the records for one month, showing how the observations are tabulated daily from the registers given by the instruments.

Table I. Part 1, gives the horizontal motion and direction of the wind for every hour of the day; the latter is indicated by a figure, the sixteen points of the compass being numbered in rotation, commencing with N.N.E. No. 1, N.E. No. 2, &c.

Part 3, Table II. is an abstract of the above, and shows the daily amount of horizontal motion from each point of the compass, and the number of hours each wind continued.

Part 4, Table II. is obtained from the Rain-register, and shows the quantity of rain in thousandths of an inch that fell in each hour during the month.

Part 2, Table I. contains the daily totals obtained from the hourly records of the wind and rain as just described.

Horizontal motion of the air in miles referred to 16 points.

1855. July.	N.N.E. 1 Miles	Hours	N.E. 2 Miles	Hours	E.N.E. 3 Miles	Hours	E. 4 Miles	Hours	E.S.E. 5 Miles	Hours	S.E. 6 Miles	Hours	S.S.E. 7 Miles	Hours	S. 8 Miles	Hours	S.S.W. 9 Miles	Hours	S.W. 10 Miles	Hours	W.S.W. 11 Miles	Hours	W. 12 Miles	Hours	W.N.W. 13 Miles	Hours	N.W. 14 Miles	Hours	N.N.W. 15 Miles	Hours	N. 16 Miles	Hours
1					9	2	1	1					65	5	52	4	27	2					10	1	27	2			25	5	8	2
2							7	2	4	1	9	2	22	4											37	5	102	10				
3																							8	1	236	19	16	2	14	2		
4																									120	9	87	11	39	4		
5			6	1	8	1	11	2	12	2			5	1	20	4									7	5	6	2	61	6	16	3
6							11	1	38	5	98	11	45	4	20	3																
7											15	3	58	9	42	5							2	1	23	2	23	4				
8									30	3	83	8	105	9	51	4																
9							57	4	117	11	62	7	21	2																		
10	1	1			18	5	70	7	66	8	17	2	11	1																		
11	2	1			3	1																	4	2	121	12	34	3	24	3	9	2
12	4	1																					4	2	11	4	14	4	56	13		
13													17	2	30	3											25	5	78	12	14	2
14													70	8	18	2	29	3	18	2	21	2			10	1	16	4	12	2		
15																					5	1	41	3	144	11	6	1	20	8		
16															1	1	13	1							175	13	51	4				
17																									549	23	22	1				
18													16	2											202	14	123	8				
19													112	10	21	3	8	1							17	2	191	8				
20																									569	22	64	2				
21													82	10									8	3	15	2	5	1	16	8		
22																	23	[illegible]	1	1			3	1			3	1	44	14		
23	31	7	4	2																									77	11	21	3
24	35	6																	9	2			10	3	12	6	20	3	9	3	6	1
25													7	1	23	2					25	2	90	6	157	13						
26									22	3	53	6	59	7	77	8																
27													27	5	66	8	15	2	17	3	11	2					1	1	16	3		
28																					39	6	11	1	41	3	97	7	55	7		
29																											188	21	19	3		
30											35	4	8	1	36	4			7	1	34	8	8	2			16	4				
31													67	7	17	2	8	1	16	2	61	6			62	6						
Sum	79	16	10	1	68	9	160	17	289	33	372	43	797	88	477	53	123	19	68	11	196	27	229	26	2565	174	1110	107	565	104	74	13

Rain in thousandths of an inch which fell during each hour.

July	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	July
1					010	040	050																		1
2					·010	·005	·005																		2
3																									3
4																									4
5																									5
6																									6
7																									7
8																									8
9																									9
10		030	053	·050	·050	·040	040	087								·045									10
11																									11
12																					·010				12
13																						·058	·032	·015	13
14		045	005		·012	028						086	012			·030		·205							14
15		·060																							15
16		005			·020	·047	088	062	·055	053	·030	030	032												16
17																									17
18																									18
19			022	·055	·015						030							·004		004					19
20																									20
21																									21
22																									22
23																						020	033	160	23
24	062	037	045	100	072	031	118	032	080	090	020	·005								055				250	24
25	045	004									020	030	070	060	085	135	·120	020	132	032	111	·135	·020	008	25
26	·022	038																							26
27		010		·036	·046	070	·065								123										27
28																									28
29																									29
30																							018	014	30
31	010	040	021				012			·040	162	081	090	·181	042										31
Sum	169	269	116	241	245	·264	318	181	135	183	242	232	204	244	250	210	124	·229	132	091	121	213	103	147	

Mean quantity per hour during the time that rain fell, 0·161.

TABLE III.—Abstract of Results derived from the Integrating Anemometer and Rain-gauge arranged according to the direction of the wind. 1852. See Plates VIII. and IX.

Points of the Compass.	Whole amount of horizontal motion of the air.	Relative amount of horizontal motion of the air. (Mean = 1·00.)	Number of hours in which the direction of the wind was referred to each point.	Relative time the direction of the wind was referred to each point. (Mean = 1·00.)	Average hourly horizontal motion of the air from each point.	Relative hourly horizontal motion of the air. (Mean = 1·00.)	Whole fall of rain arranged according to the direction of the wind.	Relative fall of rain. (Mean = 1·00.)	Whole time in hours during which rain fell.	Relative time during which rain fell. (Mean = 1·00.)	Average hourly rate at which rain fell.	Mean quantity of rain to every 1000 miles of air.
	Miles.		Hours.		Miles.		Inches.		Hours.		Inch.	Inch.
N.N.E.	2,488	0·35	*426	0·78	5·8	0·48	†2·353	1·20	34·3	0·80	0·069	0·945
N.E.	1,239	0·17	198	0·36	6·3	0·50	1·158	0·59	20·0	0·47	0·058	0·934
E.N.E.	2,799	0·39	320	0·58	8·7	0·69	1·439	0·73	24·2	0·57	0·060	0·514
E.	4,708	0·66	427	0·78	11·0	0·89	1·408	0·72	30·9	0·72	0·046	0·299
E.S.E.	4,134	0·58	423	0·77	9·8	0·79	1·487	0·76	27·5	0·64	0·054	0·360
S.E.	5,907	0·83	515	0·96	11·5	0·91	1·609	0·82	34·3	0·80	0·047	0·272
S.S.E.	18,111	2·54	1506	2·75	12·0	0·95	4·414	2·25	117·8	2·76	0·037	0·243
S.	10,452	1·48	909	1·66	11·5	0·91	1·742	0·89	66·5	1·55	0·026	0·167
S.S.W.	8,059	1·09	587	1·07	13·7	1·09	1·815	0·92	41·2	0·97	0·044	0·225
S.W.	8,311	1·22	445	0·81	18·7	1·48	2·003	1·02	41·9	0·98	0·048	0·241
W.S.W.	6,982	0·98	417	0·76	16·7	1·32	2·099	1·07	41·2	0·97	0·051	0·300
W.	7,479	1·05	397	0·69	18·8	1·49	1·670	0·85	43·9	1·03	0·038	0·223
W.N.W.	14,541	2·03	763	1·39	19·1	1·51	3·264	1·66	71·3	1·68	0·046	0·224
N.W.	7,788	1·09	476	0·87	16·4	1·30	1·147	0·53	32·2	0·76	0·033	0·147
N.N.W.	8,702	1·24	629	1·15	13·8	1·10	2·984	1·52	33·6	0·79	0·089	0·342
N.	2,576	0·36	327	0·59	7·9	0·62	0·947	0·48	22·7	0·53	0·042	0·367
Columns...1	2	3	4	5	6	7	8	9	10	11	12	13
	114,276						31·539		683·5 = 28 days, 11 hours, 30 minutes.			

* There were nineteen calm hours in the year.

† There was one calm hour during which 0·054 of an inch of rain fell.

Mean quantity of rain to every 1000 miles of air, 0·276 in.

Mean quantity per hour during the time that rain fell, 0·461

TABLE III. (*continued*). 1853.

Points of the Compass.	Whole amount of horizontal motion of the air.	Relative amount of horizontal motion of the air. (Mean=1·00.)	Number of hours in which the direction of the wind was referred to each point.	Relative time the direction of the wind was referred to each point. (Mean=1·00.)	Average hourly horizontal motion of the air from each point.	Relative hourly horizontal motion of the air. (Mean=1·00.)	Whole fall of rain arranged according to the direction of the wind.	Relative fall of rain. (Mean=1·00).	Whole time in hours during which rain fell.	Relative time during which rain fell. (Mean=1·00.)	Average hourly rate at which rain fell.	Mean quantity of rain to every 1000 miles of air.
	Miles.		Hours.		Miles.		Inches.		Hours.		Inch.	Inch.
N.N.E.	4,303	0·65	655	1·26	6·6	0·55	1·700	1·21	40·1	1·20	0·012	0·392
N.E.	1,502	0·23	240	0·46	6·3	0·53	0·843	0·60	19·4	0·58	0·043	0·561
E.N.E.	2,773	0·42	360	0·69	7·7	0·65	0·836	0·59	19·4	0·58	0·043	0·301
E.	4,262	0·64	388	0·75	11·0	0·91	1·466	1·04	27·4	0·82	0·058	0·343
E.S.E.	3,832	0 58	404	0·76	9·5	0·80	0·954	0·68	19·4	0·58	0·049	0·218
S.E.	5,929	0·89	488	0·94	12·1	1·02	1·119	0·79	24·1	0·76	0·046	0·187
S.S.E.	14,316	2·15	1233	2·23	11·6	0·97	3·124	2·22	93·0	2·27	0·034	0·218
S.	6,358	0·95	646	1·25	9·8	0·82	1·479	1·05	47·5	1·46	0·031	0·217
S.S.W.	5,160	0·78	459	0·89	11·2	0·94	1·125	0·80	36·8	1·10	0·031	0·218
S.W.	7,572	1·14	432	0·83	17·5	1·47	1·262	0·81	34·8	1·05	0·036	0·166
W.S.W.	5,952	0·90	393	0·76	15·1	1·27	1·554	1·11	48·2	1·44	0·032	0·261
W.	6,938	1·04	395	0·76	17·6	1·48	2·085	1·48	42·8	1·28	0·049	0·300
W.N.W.	14,292	2·15	814	1·57	17·6	1·48	2·146	1·53	78·2	2·23	0·027	0·150
N.W.	9,678	1·45	662	1·28	14·9	1·25	1·091	0·78	47·5	1·42	0·023	0·102
N.N.W.	9,045	1·36	696	1·34	13·0	1·08	0·914	0·65	28·8	0·86	0·032	0·100
N.	4,077	0·63	468	0·90	8·7	0·72	0·777	0·55	20·8	0·62	0·037	0·190
Columns...1	2	3	4	5	6	7	8	9	10	11	12	13
	105,989						22·475		625·2=26 days 1 hour 12 minutes.			

There were twenty-seven calm hours.
Mean quantity of rain to every 1000 miles of air, 0·212 in.
Mean quantity per hour during the time that rain fell, 0·357.

TABLE III. (*continued*). 1854.

Points of the Compass.	Whole amount of horizontal motion of the air.	Relative amount of horizontal motion of the air. (Mean = 1·00.)	Number of hours in which the direction of the wind was referred to each point.	Relative time the direction of the wind was referred to each point. (Mean = 1·00.)	Average hourly horizontal motion of the air from each point.	Relative hourly horizontal motion of the air. (Mean = 1·00.)	Whole fall of rain arranged according to the direction of the wind.	Relative fall of rain. (Mean = 1·00.)	Whole time in hours during which rain fell.	Relative time during which rain fell. (Mean = 1·00.)	Average hourly rate at which rain fell.	Mean quantity of rain to every 1000 miles of air.
	Miles.		Hours.		Miles.		Inches.		Hours.		Inch.	Inch.
N.N.E.	2,604	0·33	373	0·68	6·5	0·50	1·061	0·78	18·2	0·54	0·058	0·407
N.E.	1,020	0·13	148	0·27	6·9	0·54	0·071	0·05	9·1	0·27	0·008	0·060
E.N.E.	1,481	0·19	199	0·36	7·1	0·55	0·361	0·26	13·8	0·41	0·026	0·243
E.	2,781	0·35	256	0·47	10·5	0·81	0·442	0·32	6·3	0·19	0·070	0·158
E.S.E.	3,046	0·38	309	0·56	9·9	0·76	0·760	0·51	13·1	0·39	0·053	0·229
S.E.	4,076	0·51	374	0·68	10·9	0·85	1·471	1·07	27·5	0·82	0·053	0·369
S.S.E.	12,317	1·53	1106	2·02	11·1	0·86	2·782	2·01	72·2	2·15	0·039	0·225
S.	7,196	0·90	673	1·23	10·7	0·83	1·436	1·04	41·8	1·24	0·034	0·190
S.S.W.	5,654	0·71	496	0·91	11·4	0·88	0·960	0·69	29·7	0·88	0·032	0·169
S.W.	6,486	0·81	411	0·75	15·8	1·21	0·989	0·72	22·3	0·66	0·044	0·152
W.S.W.	8,993	1·11	561	1·02	16·5	1·26	2·558	1·85	61·0	1·81	0·042	0·284
W.	14,331	1·77	666	1·22	21·5	1·66	2·689	1·94	64·7	1·92	0·042	0·187
W.N.W.	24,622	3·07	1210	2·21	20·3	1·58	2·689	1·94	68·9	2·05	0·039	0·109
N.W.	18,393	2·29	741	1·36	24·8	1·92	1·410	1·02	42·9	1·28	0·033	0·076
N.N.W.	11,666	1·45	820	1·50	14·2	1·10	1·922	1·39	30·0	0·89	0·064	0·164
N.	3,617	0·45	413	0·76	8·8	0·68	0·574	0·42	16·0	0·48	0·035	0·158
Columns...1	2	3	4	5	6	7	8	9	10	11	12	13
	128,283						22·115		537·5 = 22 days, 9 hours, 30 minutes.			

There were four calm hours in the year.
Mean quantity of rain to every 1000 miles of air, 0·172 in.
Mean quantity per hour during the time that rain fell, 0·411.

Table III. (*continued*). 1855.

Points of the Compass.	Whole amount of horizontal motion of the air.	Relative amount of horizontal motion of the air. (Mean = 1·00.)	Number of hours in which the direction of the wind was referred to each point.	Relative time the direction of the wind was referred to each point. (Mean = 1·00.)	Average hourly horizontal motion of the air from each point.	Relative hourly horizontal motion of the air. (Mean = 1·00.)	Whole fall of rain arranged according to the direction of the wind.	Relative fall of rain. (Mean = 1·00.)	Whole time in hours during which rain fell.	Relative time during which rain fell. (Mean = 1·00.)	Average hourly rate at which rain fell.	Mean quantity of rain to every 1000 miles of air.
	Miles.		Hours.		Miles.		Inches.		Hours.		Inch.	Inch.
N.N.E.	4,456	0·67	703	1·28	6·4	0·56	0·973	0·69	34·9	1·03	0·028	0·218
N.E.	1,727	0·26	264	0·48	7·3	0·64	0·233	0·17	9·2	0·27	0·025	0·134
E.N.E.	3,014	0·46	383	0·70	7·9	0·69	0·702	0·49	14·5	0·43	0·048	0·232
E.	5,418	0·84	460	0·84	11·8	1·04	0·182	0·13	4·0	0·12	0·046	0·033
E.S.E.	3,807	0·59	401	0·73	9·4	0·83	0·599	0·42	10·8	0·32	0·056	0·157
S.E.	7,229	1·10	556	1·02	11·2	0·99	1·146	0·81	30·7	0·91	0·037	0·158
S.S.E.	12,267	1·90	1132	2·07	10·8	0·95	3·129	2·20	118·0	3·50	0·027	0·255
S.	5,728	0·88	614	1·12	9·3	0·82	1·860	1·31	45·8	1·35	0·041	0·324
S.S.W.	3,322	0·52	302	0 55	11·0	0·97	0·352	0·24	12·6	0·37	0·028	0·105
S.W.	4,742	0·73	312	0·57	15·0	1·32	1·486	1·05	18·8	0·56	0·071	0·313
W.S.W.	4,014	0·62	309	0·56	13·0	1·15	0·262	0·18	20·0	0·59	0·013	0·065
W.	7,439	1·15	413	0·76	18·0	1·59	3·912	2·77	52·2	1·55	0·075	0·525
W.N.W.	20,353	3·15	1046	1·91	19·5	1·72	2·744	1·94	64·5	1·91	0·043	0·134
N.W.	8,857	1·36	630	1·15	14·1	1·14	2·722	1·91	44·9	1·30	0·060	0·307
N.N.W.	7,883	1·22	782	1·43	10·1	0·89	0·826	0·58	25·7	0·76	0·032	0·104
N.	3,149	0·49	441	0·81	7·1	0·63	1·440	1·02	33·2	0·98	0·043	0·457
Columns...1	2	3	4	5	6	7	8	9	10	11	12	13
	103,405						22·568		539·8 = 22 days 11 hours 48 minutes.			

There were twelve calm hours.
Mean quantity of rain to every 1000 miles of air, 0·218 in.
Mean quantity per hour during the time that rain fell, 0·418.

TABLE III. (*continued*). Means for the years 1852, 1853, 1854, and 1855.

Points of the Compass.	Whole amount of horizontal motion of the air.	Relative amount of horizontal motion of the air. (Mean = 1·00.)	Number of hours in which the direction of the wind was referred to each point.	Relative time the direction of the wind was referred to each point. (Mean = 1·00.)	Average hourly horizontal motion of the air from each point.	Relative hourly horizontal motion of the air. (Mean = 1·00.)	Whole fall of rain arranged according to the direction of the wind.	Relative fall of rain. (Mean = 1·00.)	Whole time in hours during which rain fell.	Relative time during which rain fell. (Mean = 1·00.)	Average hourly rate at which rain fell.	Mean quantity of rain to every 1000 miles of air.
	Miles.		Hours.		Miles.		Inches.		Hours.		Inch.	Inch.
N.N.E.	3,463	0·49	539	0·98	6·20	0·49	1·522	0·99	31·9	0·86	0·049	0·440
N.E.	1,372	0·19	213	0·39	6·60	0·51	0·576	0·37	14·4	0 39	0·033	0·420
E.N.E.	2,517	0·36	315	0·58	7·80	0·60	0·834	0·55	18·0	0·49	0·044	0·331
E.	4,292	0·61	383	0·70	11·00	0·85	0·874	0·56	17·1	0·46	0·055	0·203
E.S.E.	3,705	0·52	384	0·70	9·60	0·74	0·935	0·60	17·7	0·48	0·053	0·252
S.E.	5,785	0·82	483	0·88	11·60	0 90	1·334	0·86	29·1	0·79	0·046	0·231
S.S.E.	14,253	2·02	1244	2·28	11·40	0·88	3·362	2·18	100·2	2·71	0·034	0 236
S.	7,433	1·05	711	1·30	10 30	0·80	1·629	1·05	50·4	1·36	0·033	0·219
S.S.W.	5,549	0·79	461	0·84	11·80	0·91	1·063	0·69	30·1	0·81	0·034	0·192
S.W.	6,778	0·96	400	0·73	16·70	1·30	1·435	0·93	29·4	0·80	0·050	0·212
W.S.W.	6,485	0·92	420	0·77	15·50	1·20	1·518	0·98	42·6	1·15	0·036	0·234
W.	9,047	1·28	468	0·85	18·90	1·46	2·589	1·68	50·9	1·37	0·051	0·286
W.N.W.	18,452	2·61	958	1·75	19·00	1·47	2·711	1·76	70·7	1·91	0·039	0·141
N.W.	11,179	1·58	627	1·15	17·40	1·35	1·592	1·03	41·9	1·13	0·037	0·142
N.N.W.	9,324	1·32	732	1·34	12·70	0·98	1·661	1·07	29·5	0·80	0·054	0·177
N.	3,355	0·48	412	0·75	7·80	0·60	0·934	0·60	23·2	0·63	0·039	0·278
Columns...1	2	3	4	5	6	7	8	9	10	11	12	13
	112,989						24·671		597·1 = 24 days 21 hours 6 minutes.			

TABLE IV.—Abstracts of Results from the Integrating Anemometer and the Pluviometer during the years 1852, 1853, 1854, and 1855, arranged according to the hours of the day. 1852.

Hours of the day. Columns......1	Mean horizontal motion of the air in miles for each hour of the day. 2	Relative horizontal motion of the air for each hour. (Mean=1·00.) 3	Whole amount of rain which fell between the hours named in the side column. 4	Relative fall of rain for each hour of the day. (Mean=1·00.) 5	Whole time in hours during which rain fell. 6	Relative time during which rain fell. (Mean=1·00.) 7	Average hourly rate at which rain fell for each hour of the day. 8
h h	Miles.		Inches.		Hours.		Inch.
12 to 1 A.M.	11·2	0·86	1·269	0·97	30·2	1·06	0·042
1 „ 2	11·4	0·88	1·242	0·95	26·2	0·92	0·048
2 „ 3	11·4	0·88	1·529	1·08	34·3	1·20	0·042
3 „ 4	11·5	0·88	1·353	1·03	35·0	1·23	0·038
4 „ 5	12·0	0·92	1·160	0·88	24·0	0·84	0·048
5 „ 6	12·0	0·92	1·386	1·06	30·2	1·06	0·046
6 „ 7	12·2	0·94	1·398	1·07	28·2	0·99	0·050
7 „ 8	12·7	0·98	1·555	1·19	28·8	1·01	0·054
8 „ 9	13·4	1·03	1·459	1·11	31·6	1·11	0·046
9 „ 10	13·7	1·05	1·090	0·83	28·8	1·01	0·038
10 „ 11	14·4	1·11	1·389	1·07	27·5	0·97	0·050
11 „ 12	15·1	1·16	0·936	0·71	26·8	0·94	0·035
12 „ 1 P.M.	15·2	1·17	1·305	0·99	25·4	0·89	0·051
1 „ 2	15·5	1·19	1·178	0·89	26·7	0·94	0·044
2 „ 3	15·2	1·17	1·359	1·04	26·1	0·92	0·051
3 „ 4	14·9	1·14	1·476	1·13	26·7	0·94	0·055
4 „ 5	14·5	1·11	1·241	0·95	35·6	1·25	0·035
5 „ 6	13·6	1·04	1·262	0·96	26·7	0·94	0·047
6 „ 7	13·1	1·01	1·354	1·03	30·9	1·08	0·044
7 „ 8	12·7	0·98	0·851	0·64	21·9	0·77	0·039
8 „ 9	12·2	0·94	1·594	1·21	28·9	1·01	0·055
9 „ 10	11·6	0·89	1·306	1·00	24·0	0·84	0·054
10 „ 11	11·5	0·88	1·356	1·03	29·5	1·04	0·046
11 „ 12	11·5	0·88	1·545	1·18	29·5	1·04	0·052
1853.							
12 to 1 A.M.	10·3	0·85	0·607	0·68	16·1	0·69	0·037
1 „ 2	10·5	0·87	0·833	0·93	21·4	0·91	0·039
2 „ 3	10·7	0·88	0·607	0·68	21·4	0·91	0·026
3 „ 4	10·5	0·87	0·766	0·85	26·1	1·12	0·029
4 „ 5	10·8	0·89	1·049	1·17	30·2	1·29	0·035
5 „ 6	10·8	0·89	0·915	1·02	27·5	1·18	0·034
6 „ 7	11·3	0·93	1·089	1·21	30·8	1·32	0·035
7 „ 8	12·0	0·99	1·249	1·38	30·8	1·32	0·040
8 „ 9	12·5	1·03	1·046	1·17	32·8	1·40	0·032
9 „ 10	13·2	1·09	1·185	1·34	30·1	1·29	0·039
10 „ 11	13·8	1·14	1·577	1·76	30·1	1·29	0·052
11 „ 12	14·2	1·17	0·860	0·96	22·1	0·94	0·039
12 „ 1 P.M.	14·5	1·20	1·011	1·13	27·5	1·14	0·037
1 „ 2	14·7	1·21	1·173	1·31	28·8	1·24	0·041
2 „ 3	14·4	1·19	0·818	0·91	25·5	1·04	0·032
3 „ 4	14·0	1·16	0·811	0·90	26·1	1·12	0·031
4 „ 5	13·5	1·12	1·047	1·17	31·5	1·35	0·033
5 „ 6	12·7	1·05	0·920	1·03	30·8	1·32	0·030
6 „ 7	11·7	0·97	1·108	1·24	30·1	1·29	0·037
7 „ 8	11·2	0·93	0·788	0·88	28·1	1·20	0·028
8 „ 9	11·0	0·91	0·913	1·02	21·4	0·91	0·042
9 „ 10	10·9	0·90	0·681	0·76	20·1	0·86	0·034
10 „ 11	10·5	0·87	0·631	0·70	18·1	0·78	0·035
11 „ 12	10·6	0·88	0·820	0·91	21·4	0·91	0·038

TABLE IV. (*continued*). 1854.

Hours of the day. Columns......1	Mean horizontal motion of the air in miles for each hour of the day. 2	Relative horizontal motion of the air for each hour. (Mean = 1·00.) 3	Whole amount of rain which fell between the hours named in the side column. 4	Relative fall of rain for each hour of the day. (Mean = 1·00.) 5	Whole time in hours during which rain fell. 6	Relative time during which rain fell. (Mean = 1·00.) 7	Average hourly rate at which rain fell for each hour of the day. 8
h h	Miles.		Inches.		Hours.		Inch.
12 to 1 A.M.	12·8	0·90	0·762	0·83	18·2	0·77	0·042
1 „ 2	12·8	0·90	0·415	0·45	20·4	0·92	0·020
2 „ 3	12·8	0·90	0·556	0·60	18·7	0·78	0·030
3 „ 4	13·1	0·92	1·031	1·12	28·6	1·26	0·036
4 „ 5	12·6	0·89	1·289	1·40	31·8	1·42	0·041
5 „ 6	12·6	0·89	1·247	1·35	26·0	1·16	0·048
6 „ 7	12·8	0·90	1·263	1·37	27·3	1·22	0·046
7 „ 8	13·6	0·96	1·112	1·21	26·2	1·18	0·043
8 „ 9	14·0	0·99	0·593	0·63	20·2	0·90	0·029
9 „ 10	14·9	1·05	0·881	0·96	20·2	0·90	0·043
10 „ 11	15·2	1·07	0·706	0·76	21·8	0·97	0·032
11 „ 12	15·5	1·09	0·936	1·01	26·3	1·17	0·036
12 „ 1 P.M.	16·3	1·15	0·820	0·89	20·1	0·90	0·039
1 „ 2	16·6	1·17	1·026	1·11	20·0	0·90	0·051
2 „ 3	16·3	1·15	0·714	0·78	17·4	0·78	0·041
3 „ 4	16·0	1·13	0·776	0·84	16·9	0·75	0·046
4 „ 5	15·6	1·10	1·090	1·18	20·9	0·93	0·052
5 „ 6	14·9	1·05	0·733	0·79	19·1	0·85	0·038
6 „ 7	14·5	1·02	0·836	0·91	26·6	1·19	0·031
7 „ 8	14·0	0·99	1·052	1·14	25·4	1·13	0·041
8 „ 9	13·5	0·96	1·518	1·64	21·8	0·97	0·069
9 „ 10	13·3	0·94	1·065	1·16	19·6	0·87	0·054
10 „ 11	13·3	0·94	0·734	0·80	22·8	1·01	0·033
11 „ 12	13·1	0·92	0·860	0·93	21·2	0·94	0·041
1855.							
12 to 1 A.M.	10·5	0·89	0·657	0·69	22·2	0·99	0·029
1 „ 2	10·5	0·89	0·971	1·03	24·6	1·09	0·039
2 „ 3	10·3	0 87	0·771	0·82	21·4	0·95	0·036
3 „ 4	10·4	0·87	0·827	0·88	25·1	1·11	0·033
4 „ 5	10·4	0·87	0·827	0·88	26·5	1·18	0·031
5 „ 6	10·5	0·89	0·648	0·68	20·3	0·90	0·032
6 „ 7	10·8	0·91	0·795	0·84	22·9	1·01	0·035
7 „ 8	11·5	0·97	0·856	0·91	24·3	1·08	0·035
8 „ 9	11·6	0·97	0·666	0·71	25·3	1·12	0·027
9 „ 10	12·3	1·04	0·880	0·93	26·0	1·16	0·034
10 „ 11	13·1	1·11	0·768	0·81	20·2	0·90	0·038
11 „ 12	13·5	1·14	1·121	1·19	25·4	1·12	0·044
12 „ 1 P.M.	13·9	1·18	1·445	1·53	23·3	1·03	0·062
1 „ 2	14·2	1·20	1·756	1·86	19·7	0·87	0·081
2 „ 3	14·0	1·18	0·933	0·98	15·0	0·66	0·062
3 „ 4	13·5	1·14	0·778	0·83	23·0	1·02	0·034
4 „ 5	13·0	1·11	0·887	0·94	19·9	0·88	0·044
5 „ 6	12·6	1·06	1·608	1·69	20·6	0·91	0·078
6 „ 7	11·6	0·97	1·025	1·08	19·8	0·88	0·052
7 „ 8	11·2	0·95	0·916	0·96	24·7	1·09	0·037
8 „ 9	10·8	0·91	0·971	1·03	19·9	0·88	0·049
9 „ 10	10·8	0·91	0·653	0·68	22·8	1·01	0·029
10 „ 11	10·7	0·91	0·709	0·75	25·1	1·11	0·028
11 „ 12	10·6	0·89	1·100	1·17	21·8	0·97	0·050

Table IV. (*continued*).—Means for the years 1852, 1853, 1854, and 1855.

Hours of the day. Columns......1	Mean horizontal motion of the air in miles for each hour of the day. 2	Relative horizontal motion of the air for each hour. (Mean=1·00.) 3	Whole amount of rain which fell between the hours named in the side column. 4	Relative fall of rain for each hour of the day. (Mean=1·00.) 5	Whole time in hours during which rain fell. 6	Relative time during which rain fell. (Mean=1·00.) 7	Average hourly rate at which rain fell for each hour of the day. 8
h h	Miles.		Inches.		Hours.		Inch.
12 to 1 A.M.	11·2	0·88	0·824	0·80	21·7	0·87	0·037
1 „ 2	11·3	0·89	0·865	0·84	23·1	0·93	0·036
2 „ 3	11·3	0·89	0·866	0·84	23·9	0·96	0·033
3 „ 4	11·4	0·90	0·994	0·96	28·7	1·14	0·034
4 „ 5	11·4	9·90	1·081	1·05	28·1	1·13	0·039
5 „ 6	11·5	0·90	1·049	1·02	26·0	1·05	0·040
6 „ 7	11·8	0·93	1·136	1·10	27·3	1·10	0·041
7 „ 8	12·4	0·97	1·193	1·16	27·5	1·10	0·043
8 „ 9	12·9	1·01	0·941	0·91	27·5	1·10	0·033
9 „ 10	13·5	1·06	1·009	0·97	26·3	1·06	0·036
10 „ 11	14·1	1·11	1·110	1·08	24·9	1·00	0·043
11 „ 12	14·6	1·15	0·963	0·93	25·1	1·01	0·038
12 „ 1 P.M.	15·0	1·18	1·145	1·11	24·1	1·00	0·047
1 „ 2	15·2	1·19	1·283	1·25	23·8	0·96	0·054
2 „ 3	15·0	1·18	0·956	0·93	21·0	0·84	0·046
3 „ 4	14·6	1·15	0·960	0·93	23·2	0·93	0·041
4 „ 5	14·1	1·11	1·066	1·03	27·0	1·09	0·041
5 „ 6	13·4	1·05	1·131	1·10	24·3	1·00	0·048
6 „ 7	12·7	1·00	1·081	1·05	26·8	1·09	0·041
7 „ 8	12·3	0·97	0·902	0·90	25·0	1·01	0·036
8 „ 9	11·9	0·93	1·249	1·21	23·0	0·93	0·054
9 „ 10	11·6	0·91	0·926	0·90	21·6	0·87	0·043
10 „ 11	11·5	0·90	0·857	0·83	23·9	0·96	0·035
11 „ 12	11·4	0·90	1·081	1·05	23·5	0·94	0·045

The accompanying diagrams I have prepared in order to convey a more accurate and comprehensive perception of the results than can be obtained by consulting tables and figures, and also to enable a comparison of the different years to be made with greater facility.

The Charts contained in Plate VII. are reduced from some very large and carefully prepared tracings laid down by Mr. Hartnup, directly from the worked paper of the integrating instrument, according to the method first suggested by Dr. Whewell; on examining these tracings for each year, they will be found to bear but little resemblance to one another; and if we refer to those projected in a similar manner for Plymouth, by Sir William Harris, during the years 1841, 1842, and 1843*, as great a difference will be found to exist, one feature only being at all observable throughout, and that is the general tendency of the wind from the W. towards the E.; this appears to have been the case to a remarkable degree in Liverpool in the year 1854; in other respects but little or no resemblance can be traced. Notwithstanding this apparent dissimilarity when thus illustrated, it will be found, that if the various winds, instead of being projected in the order in which they succeeded one another, are classified so as to show the relative amount of each, for the different years, a remarkable coincidence is observable. A reference

* See Report of the British Association for 1844.

to the first row of diagrams on Plate VIII. will render this fact very strikingly apparent; these are all drawn to one scale, so that the comparative motion of the air from each point, for the different years, may be seen at a glance; they are on precisely the same plan as those I brought before the British Association in 1840*, the difference being that the mileage of each wind is in this case regarded instead of the force. To this mode of making diagrams of the wind, the title of "Wind Stars" has lately been given by Captain Fitzroy. I had prepared similar diagrams for each month and quarter of the year, but have reserved these until a longer range of averages had been obtained.

In the second row of diagrams, Plate VIII., the *hours* during which each wind has lasted are compared, instead of the number of miles; in these, the resemblance the different years bear to one another is even more striking.

The average hourly rate at which each wind travels, is shown in the third row of diagrams, Plate VIII.; from this it will be seen that all those winds having a westerly bearing travel very much the fastest: those from the S. to the E. proceed at a much slower rate, while such as come from the North-east average but a little more than one-third the rate of the Westerly winds (for the exact rates see Table III., Column 6).

With reference to the results obtained from the Rain-registers, the first row of diagrams, Plate IX., gives a comparative view of the amount of rain which accompanied each wind, while the second row exhibits the number of hours it occupied in falling; from these the hourly rate is at once obtained, and the result is shown in the third row of diagrams on the same Plate. In addition to this, the quantity of rain compared with the amount of air that passed over the station has been taken out (see Table III. column 2), and a diagram (see Plate X. fig. 2) is given, showing the mean quantity of rain that falls to every thousand miles of air from each point of the compass. By this it will be observed that the North-Easterly winds, which are smallest in amount, bring with them a much larger proportion of rain than those from any other point.

TABLE V.—Whole amount of rain that fell between each hour. See Plate X. fig. 1, and Table IV. col. 4.

A.M.	12 to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11	11 to 12
1852.	1·269	1·242	1·529	1·353	1·160	1·386	1·398	1·555	1·459	1·090	1·389	0·936
1853.	0·607	0·833	0·607	0·766	1·049	0·915	1·089	1·249	1·046	1·185	1·577	0·860
1854.	0·762	0·415	0·556	1·031	1·289	1·247	1·263	1·112	0 593	0·881	0·706	0·936
1855.	0·657	0·971	0·771	0·827	0·827	0·648	0·795	0·856	0·666	0·880	0·768	1·121
Mean	0·824	0·865	0·866	0·994	1·081	1·049	1·136	1·193	0·941	1·009	1·110	0·963
P.M.	12 to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11	11 to 12
1852.	1·305	1·178	1·359	1·476	1·241	1·262	1·354	0·851	1·594	1·306	1·356	1·545
1853.	1·011	1·173	0·818	0·811	1·047	0 920	1·108	0·788	0·913	0·681	0·631	0·820
1854.	0·820	1·026	0·714	0·776	1·090	0·733	0·836	1·052	1·518	1·065	0·734	0·860
1855.	1·445	1·756	0·933	0·778	0·887	1·608	1·025	0·916	0·971	0·653	0·709	1·100
Mean	1·145	1·283	0·956	0·960	1·066	1·131	1·081	0·902	1·249	0·926	0·857	1·081

* See Report of the British Association at Glasgow, 1840.

Table VI.—Mean hourly horizontal motion of the air in miles for each month. See Plate X. fig. 3.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1852.	19·2	18·6	9·0	9·3	12·6	13·5	10·5	10·6	11·2	11·6	12·6	17·6
1853.	15·3	12·0	10·3	17·0	11·3	9·8	15·2	10·7	12·3	11·7	9·8	9·6
1854.	16·0	19·2	13·9	12·8	10·6	12·6	10·4	11·4	12·8	13·2	13·7	23·9
1855.	9·6	9·8	12·6	13·8	12·5	12·4	9·6	14·6	8·1	13·9	8·5	15·5
Mean	15·0	14·9	11·45	13·2	11·75	12·1	11·4	11·8	11·1	12·6	10·9	16·85

Winter. Dec., Jan., Feb.	Spring. Mar., Apr., May.	Summer. June, July, Aug.	Autumn. Sept., Oct., Nov.
15·6 miles per hour.	12·1 miles per hour.	11·8 miles per hour.	11·5 miles per hour.

Table VII.—Horizontal motion of the air for the years 1852, 1853, 1854, and 1855.

	Miles.	Hours.	Calm hours.	Total number of hours in the year.	Mean rate per hour per annum.
1852.*	114,276	8765	19	8784	13·00
1853.	105,989	8733	27	8760	12·09
1854.	128,283	8756	4	8760	14·64
1855.	103,405	8748	12	8760	11·80
Mean	112,989	8750	15·5	8766	12·90

* Leap year.

The sums of all the changes in the direction of the wind are in the following order:—

N.E.S.W.N.
- 28 revolutions in 1852.
- 24 revolutions in 1853.
- 26 revolutions in 1854.
- 24 revolutions in 1855.

N.W.S.E.N.
- 12 revolutions in 1852.
- 12 revolutions in 1853.
- 2 revolutions in 1854.
- 10 revolutions in 1855.

The excess of the direct over the retrograde motion was therefore—
in 1852, Sixteen revolutions,
in 1853, Twelve revolutions,
in 1854, Twenty-four revolutions,
in 1855, Fourteen revolutions.

Table V. gives the hourly amount of rain, and is illustrated in fig. 1, Plate X. As far as four years are capable of indicating, it would appear that the minimum amount of rain falls during the first three hours after midnight, and that there are three periods in the day when an increased amount of rain falls, namely, between seven and eight o'clock in the morning, between one and two in the middle of the day, and between eight and nine in the evening; but before any satisfactory conclusions can be arrived at on this subject, it will be necessary to obtain averages for a longer period.

Table VI. gives the average hourly motion of the air in miles for each month, direction not being regarded. The curves shown in fig. 3, Plate X., exhibit the comparative results given in this table, by which it appears that the greatest amount of motion in the air takes place in the months of Decem-

ber, January, and February. November seems to be the stillest month in the year, and March, which is usually considered such a windy month, is in fact one of the four in which the least amount of motion in the air occurs, while April is only surpassed by the three winter months mentioned above.

Table VIII., like the preceding, gives the mean hourly motion of the air without regard to direction, but instead of referring to the months, shows the amount of motion between any one hour of the day and the next following, as explained in the heading of the table. This is illustrated in Plate XI., a reference to which will render any lengthened explanation here unnecessary. I would merely call attention to the coincidence between these curves and those of temperature; they also agree in a striking manner with the curves I laid down in a similar way from the observations taken in Birmingham with the Force Anemometer, and which appear in the Report of the British Association for 1840, already alluded to.

In the foregoing Tables in this Report, the horizontal motion of the air, obtained from Dr. Robinson's revolving cups, is tabulated in preference to the force, not only because it can be recorded more definitely, but as affording many interesting results respecting the velocity of various winds; but when observations from different stations have to be compared, the force register will be found of great utility, by exhibiting the sudden and extreme changes which frequently take place, not only in storms, but in the more regular currents of the atmosphere, when those marked and important indications become of peculiar interest: on this account I consider both modes of registration as desirable.

Important as are the Observations at the Liverpool Observatory, contained in the foregoing Tables, their value will be much enhanced when regarded in connexion with those at other places; and this leads me to repeat a proposition to which I have on more than one occasion taken the liberty of calling attention, namely, the expediency of carrying out Anemometrical Observations on an extended scale, especially further South, where the action of the sun, that great disturbing cause, is more marked and regular; after this is in operation, the observations may be advantageously carried Northwards to our own country, where the changes are more complex. We cannot hope to determine the laws of the great atmospheric currents from observations limited to such an ever-varying condition of the elements as exists in these islands, which are situated in a region of variable winds producing an equally varied climate, and lie, moreover, on the borders of a great continent as well as a vast ocean; but if such observations were combined with a series of continuous anemometrical records of the atmospheric currents, commencing nearer the equator, I think it would do more towards the advancement of the Science of Meteorology than any other class of observations.

The very valuable observations that are being taken by Captains of vessels carrying meteorological instruments supplied by Her Majesty's Government, under the management of Captain Fitzroy, as well as those from the American Government, under the superintendence of Lieutenant Maury, are of great and immediate practical value; but I am of opinion, that if a number of standard points were to be selected, and a continuous series of self-registered observations obtained, the investigations that are now going on would be greatly benefited and advanced. Detached observations on the wind taken at intervals on board ship, are most valuable in filling up the spaces between fixed and unerring self-recording instruments, but are scarcely sufficient to procure such exact knowledge of the variations as it is so necessary to obtain, if the movements of the air are to be

Table VIII.—Showing the mean horizontal motion of the air in miles for the years ending November 30,

1851–52.	0-1 A.M.	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10
Dec., Jan., Feb.	13·8	14·1	14·3	15·1	15·4	14·9	14·6	15·0	15·5	15·6
March, April, May	8·5	8·4	8·0	7·9	8·0	8·4	8·8	9·0	10·3	11·3
June, July, August	9·5	10·0	10·2	9·5	10·0	10·2	11·3	12·2	12·8	13·5
Sept., Oct., Nov.	10·7	10·9	10·3	10·8	10·9	10·6	10·5	10·8	11·7	11·8
1852–53.										
Dec., Jan., Feb.	13·5	13·9	14·7	14·6	15·5	15·4	15·5	16·0	15·4	16·1
March, April, May	10·3	10·5	11·0	10·8	11·1	10·9	11·6	12·6	13·7	14·5
June, July, August	10·0	9·6	9·4	9·3	9·7	9·6	10·1	11·6	12·4	12·8
Sept., Oct., Nov.	10·0	10·3	10·4	10·3	10·2	10·7	10·7	11·4	11·7	11·8
1853–54.										
Dec., Jan., Feb.	13·7	13·2	13·2	13·2	13·2	13·9	14·0	14·1	14·1	14·9
March, April, May	10·7	10·2	10·4	11·1	10·6	10·6	10·8	11·8	12·7	13·4
June, July, August	9·5	9·6	9·4	9·4	9·4	9·0	10·0	11·1	12·1	12·8
Sept., Oct., Nov.	12·6	12·2	12·4	12·7	12·6	12·3	12·2	12·7	12·8	13·7
1854–55.										
Dec., Jan., Feb.	13·3	13·8	13·7	13·6	13·0	13·5	13·4	13·7	13·7	14·2
March, April, May	11·1	10·9	10·9	11·3	11·1	11·4	11·9	12·4	13·1	13·6
June, July, August	10·4	10·7	10·6	10·8	10·6	11·1	11·6	12·2	12·6	12·9
Sept., Oct., Nov.	8·9	8·6	8·9	8·8	8·8	8·6	8·9	9·3	10·1	10·8
Mean for the years										
Dec., Jan., Feb.	13·57	13·75	13·97	14·12	14·27	14·42	14·37	14·70	14·67	15·25
March, April, May	10·15	10·00	10·07	10·27	10·20	10·32	10·77	11·45	12·45	13·25
June, July, August	9·85	9·97	9·90	9·75	9·92	9·97	10·75	11·77	12·47	13·00
Sept., Oct., Nov.	10·55	10·50	10·50	10·65	10·62	10·55	10·57	11·05	11·57	12·02
Mean	11·03	11·05	11·11	11·19	11·25	11·31	11·61	12·24	12·79	13·38

charted, and we are to hope for a discovery of the laws that regulate them. I would propose, therefore, that stations be established to aid in carrying out an Anemometrical Survey of the Atlantic; in the first place at Bermuda, the Azores, and Madeira; also one or two on the South Coast of England, and on some Southerly point in Ireland. To these it would be desirable, if possible, to add two or three stations on the Atlantic Coasts of Europe and America. This plan, which I suggested at the Physical Section of the British Association in 1849, would, I believe, be the most efficient and expeditious mode of obtaining the knowledge required, and the advantages to be derived from it would more than compensate any difficulty. Nor need the expense be very great; for instruments might be constructed that would continue their record for several days together, and thus require occasional attention only. I should recommend commencing with the three first-named insular stations, as being the most important. In addition to the information to be obtained respecting the general currents of the air, the subject of rotatory storms might be investigated. There is much to be discovered respecting them, which self-registering instruments alone are likely to supply. That rotatory storms do take place, there can be no doubt; but I believe the rotatory portion is much less than is supposed, and may not always be in contact with the earth. The present theory respecting them does not account for many phænomena, and can only be regarded as furnishing a rough approximation to their real motion.

between any one hour of the day and the next hour following, for each of the seasons, 1852, 1853, 1854, and 1855. See Plate XI.

10–11	11–12	12–13	13–14	14–15	15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24
16·9	17·8	17·7	18·3	18·2	17·8	17·3	16·0	15·8	16·0	15·7	15·3	15·0	14·5
11·6	12·7	12·8	13·4	13·2	13·1	12·3	11·8	10·6	9·9	9·0	9·0	8·7	8·8
13·7	14·0	13·8	13·8	13·5	13·3	13·2	12·0	12·1	10·6	9·8	9·1	9·2	9·6
12·2	13·0	13·4	13·8	13·7	13·3	13·2	12·3	11·7	12·0	11·9	11·7	11·3	10·9
16·8	17·2	17·1	17·0	16·0	15·0	14·4	13·5	13·1	13·4	13·6	13·5	13·3	14·0
15·1	15·9	15·8	16·2	15·9	15·7	15·5	14·3	12·8	11·3	10·9	11·0	10·6	10·7
13·7	13·8	14·6	14·8	15·0	15·0	14·8	13·5	12·7	11·9	10·7	10·4	9·9	10·3
12·4	13·1	13·4	13·6	13·4	13·0	12·2	11·3	10·4	10·9	10·6	10·2	10·0	10·0
15·5	15·6	15·8	16·1	16·2	15·6	14·9	14·5	14·8	14·9	15·0	14·0	14·2	14·3
13·7	13·8	15·0	15·3	15·3	15·1	14·5	13·7	13·1	11·9	11·4	11·0	11·0	11·1
12·7	12·7	13·6	14·5	14·0	13·5	13·8	13·0	11·8	11·0	10·2	10·4	10·2	9·8
14·2	14·7	15·1	14·8	14·1	14·1	13·7	13·4	13·3	13·3	13·0	13·1	13·4	13·0
14·8	15·8	16·5	16·6	16·1	15·8	15·3	15·3	14·7	14·3	13·7	13·8	13·7	13·4
14·8	15·5	16·0	16·3	16·3	15·7	15·1	14·9	13·3	12·2	11·4	11·7	11·7	11·1
13·6	13·9	14·1	14·3	14·0	13·7	13·7	12·7	12·5	11·8	10·9	10·7	10·9	10·7
11·8	12·0	12·6	13·1	12·6	11·9	11·4	10·8	9·9	9·3	9·0	9·2	9·0	9·1
1852, 1853, 1854, and 1855.													
16·00	16·60	16·77	17·00	16·62	16·05	15·47	14·82	14·60	14·60	14·50	14·15	14·05	14·05
13·80	14·47	14·90	15·30	15·17	14·90	14·35	13·69	12·45	11·32	10·67	10·67	10·50	10·42
13·42	13·60	14·02	14·35	14·12	13·87	13·87	12·80	12·27	11·32	10·40	10·15	10·05	10·10
12·65	13·20	13·62	13·82	13·45	13·07	12·62	11·95	11·32	11·37	11·12	11·05	10·92	10·75
13·96	14·46	14·82	15·11	14·84	14·47	14·07	13·31	12·66	12·15	11·67	11·50	11·38	11·33

Many interesting and important results remain to be worked out from the very accurate and complete series of observations that have been recorded at Liverpool, under the skilful and vigilant care of Mr. Hartnup. His Tables, which will increase in value with their progressive accumulation, are admirably arranged, and contain much more information than any I have hitherto seen.

The following Table exhibits the extreme pressure of the wind in pounds on the square foot, and the greatest horizontal motion of the air between any one hour and the next hour following, for all the gales during the four years in which the pressure has reached fifteen pounds on the square foot.

Date.		Extreme pressure on the square foot.	Time at which it occurred.	Greatest velocity of the air between any one hour and the next hour following.	Hours between which it occurred.	Direction of the wind.
1852.		Pounds.	h m	Miles.	h h	
January	3	16	7 30 P.M.	50	8 & 9 P.M.	S.W.
,,	4	28	5 30 A.M.	53	5 ,, 6 A.M.	W.N.W.
,,	7	19	2 30 P.M.	50	3 ,, 4 P.M.	W.N.W.
,,	8	18	4 12 P.M.	39	4 ,, 5 P.M.	S.
,,	9	29	3 0 A.M.	62	4 ,, 5 A.M.	W.N.W.
,,	15	16	11 30 A.M.	44	11 ,, 12 A.M.	W.
,,	16	15	0 45 P.M.	40	12 ,, 1 P.M.	W.
,,	21	18	7 30 P.M.	46	8 ,, 9 P.M.	W.S.W.
,,	25	16	4 30 P.M.	27	4 ,, 5 P.M.	S.S.W.
,,	30	17	0 20 P.M.	38	12 ,, 1 P.M.	W.N.W.
February	6	15	4 45 A.M.	44	4 ,, 5 A.M.	W.N.W.
,,	9	18	4 20 A.M.	47	5 ,, 6 A.M.	N.N.W.
,,	16	22	7 42 P.M.	50	7 ,, 8 P.M.	W.N.W.
,,	17	16	7 38 P.M.	47	8 ,, 9 P.M.	W.
,,	18	15	8 30 A.M.	47	6 ,, 7 A.M.	N.W.
May	14	17	9 30 A.M.	49	9 ,, 10 A.M.	W.N.W.
December	25	42	4 45 A.M.	70	4 ,, 5 A.M.	W.S.W.
,,	27	42	6 48 A.M.	71	8 ,, 9 A.M.	S.W.
1853.						
January	6	19	10 40 A.M.	38	6 ,, 7 P.M.	W.N.W.
,,	11	17	10 12 A.M.	47	10 ,, 11 A.M.	W.
,,	12	17	7 50 A.M.	47	9 ,, 10 A.M.	S.W.
February	26	33	11 40 A.M.	60	12 ,, 1 P.M.	N.N.W.
April	1	23	11 0 A.M.	51	12 ,, 1 P.M.	S.W.
,,	7	16	2 30 P.M.	42	2 ,, 3 P.M.	W.N.W.
September	25	37	7 50 P.M.	65	7 ,, 8 P.M.	N.N.W.
,,	26	24	2 12 A.M.	56	2 ,, 3 A.M.	N.N.W.
1854.						
January	20	22	0 42 P.M.	30	9 ,, 10 P.M.	W.S.W.
,,	24	19	2 54 A.M.	34	5 ,, 6 A.M.	S.
,,	25	16	3 36 P.M.	34	7 ,, 8 P.M.	W.S.W.
,,	26	43	10 42 A.M.	53	9 ,, 10 A.M.	W.
,,	27	20	7 24 P.M.	53	7 ,, 8 P.M.	S.W.
February	6	15	0 36 A.M.	43	1 ,, 2 A.M.	W.
,,	8	21	1 6 A.M.	45	1 ,, 2 A.M.	W.N.W.
,,	15	15	4 24 A.M.	40	5 ,, 6 A.M.	N.W.
,,	17	27	8 6 P.M.	56	8 ,, 9 P.M.	N.W.
,,	18	31	3 54 A.M.	56	4 ,, 5 A.M.	W.N.W.
,,	22	18	2 18 P.M.	35	3 ,, 4 P.M.	S.S.W.
October	22	24	6 42 A.M.	44	6 ,, 7 A.M.	N.W.
December	2	16	5 6 A.M.	47	6 ,, 7 A.M.	W.N.W.
,,	3	25	3 54 P.M.	45	11 ,, 12 P.M.	W.N.W.
,,	4	17	1 6 A.M.	43	0 ,, 1 A.M.	W.N.W.
,,	5	16	11 18 A.M.	45	8 ,, 9 P.M.	W.
,,	15	17	8 42 A.M.	44	8 ,, 9 A.M.	W.
,,	22	27	8 12 A.M.	48	8 ,, 9 A.M.	W.N.W.
,,	25	20	1 24 P.M.	48	1 ,, 2 P.M.	W.N.W.
,,	26	16	10 36 A.M.	40	12 ,, 1 P.M.	W.
,,	27	15	2 48 A.M.	43	3 ,, 4 A.M.	W.N.W.
,,	31	15	10 18 P.M.	46	10 ,, 11 P.M.	N.W.
1855.						
January	1	19	1 24 A.M.	48	3 ,, 4 A.M.	W.N.W.
March	1	15	2 0 P.M.	46	2 ,, 3 P.M.	W.N.W.
,,	18	15	2 30 P.M.	46	2 ,, 3 P.M.	W.N.W.
April	10	24	0 5 P.M.	51	0 ,, 1 P.M.	W.N.W.
,,	11	18	2 45 A.M.	48	3 ,, 4 A.M.	W.N.W.
October	24	16	7 15 A.M.	40	5 ,, 6 A.M.	W.

PROVISIONAL REPORTS.

On the Strength of Boiler Plates. By WM. FAIRBAIRN, *F.R.S.*

On Boiler Explosions. By WM. FAIRBAIRN, *F.R.S.*

Report of the Committee appointed by the British Association for the Advancement of Science, to investigate and report upon the changes which have taken place in the Channels of the Mersey during the last fifty years, to the General Meeting at Glasgow, 1855.

YOUR Committee have to report that they have been engaged in the examination of various documents which contain evidence upon the subject confided to them; and they have pleasure in acknowledging the courteous assistance they have received from the Duchy of Lancaster, the Mayor and Town Council of Liverpool, the Dock Committee of Liverpool, and James Rendel, Esq., C.E., who have granted access to the various documents which they severally possess, calculated to give information upon the subject.

As, however, the charts, reports, and other papers are for the most part very valuable, the several custodians naturally decline to allow them to be removed from their respective places of deposit; and it has therefore been found necessary to transcribe such portions as are required for the purposes of the inquiry. Should the Association consider that the inquiry should be prosecuted, your Committee hope to be entrusted with a grant of £100 to be applied to the purpose.

As Sir Philip Egerton for several years past has given considerable attention to the changes in the Mersey, your Committee are desirous of enjoying the advantage of his assistance, and hope that he may be included in their reappointment.

The inquiry into the causes of the present state of the Mersey has so important a relation to harbour engineering specially, and to certain sciences the knowledge of which is necessary for its operations, that your Committee hope that they shall be permitted to continue that inquiry with the means requisite for giving it practical efficiency. HARROWBY.

First Report of the Liverpool Committee on the Deviations of the Compass Needle in Iron and other Vessels occasioned by Inductive or Polar Magnetism. By J. B. YATES, *F.A.S., Chairman to the Compass Committee, and* JOHN GRANTHAM, *C.E., Hon. Sec.*

On Life Boats. By A. HENDERSON.

On the Friction of Disks in Water and on Centrifugal Pumps. By JAMES THOMSON, *C.E.*

A Report of one Day's Dredging by the Belfast Dredging Committee was read by Mr. PATTERSON, *who exhibited specimens of* Virgularia mirabilis, *with Drawings of the Polypes, by* Professor WYVILLE THOMSON.

NOTICES AND ABSTRACTS

OF

MISCELLANEOUS COMMUNICATIONS TO THE SECTIONS.

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MATHEMATICS AND PHYSICS.

Mathematics.

On the Porism of the in-and-circumscribed Triangle.
By A. Cayley, *M.A., F.R.S.*

The porism of the in-and-circumscribed triangle in its most general form relates to a triangle, the angles of which lie in fixed curves, and the sides of which touch fixed curves, but at present I consider only the case in which the angles lie in one and the same fixed curve, which for greater simplicity I assume to be a conic. We have therefore a triangle ABC, the angles of which lie in a fixed conic $\mathfrak{S}$, and the sides of which touch the fixed curves $\mathfrak{A}$, $\mathfrak{B}$, $\mathfrak{C}$. And if we consider the conic $\mathfrak{S}$ and the curves $\mathfrak{A}$, $\mathfrak{B}$ as given, the curve $\mathfrak{C}$ will be the envelope of the side AB of the triangle. Suppose that the curves $\mathfrak{A}$, $\mathfrak{B}$ are of the classes m, n respectively, there is no difficulty in showing that the curve $\mathfrak{C}$ is of the class $2mn$. But the curve $\mathfrak{C}$ has in general double tangents, forming two distinct groups, the first group arising from quadrilaterals inscribed in the conic $\mathfrak{S}$, and such that two opposite sides touch the curve $\mathfrak{A}$ and the other two opposite sides touch the curve $\mathfrak{B}$, the second group arising from quadrilaterals inscribed in the conic $\mathfrak{S}$, and such that two adjacent sides touch the curve $\mathfrak{A}$ and the other two adjacent sides touch the curve $\mathfrak{B}$. The number of double tangents of the first group is $mn\,(mn-1)$, and the number of double tangents of the second group is $mn\,(mn-m-n+1)$; the number of double tangents of the two groups is therefore $mn\,(2mn-m-n)$. The curve $\mathfrak{C}$ has not in general any inflexions, hence being of the class $2mn$ and having $mn\,(2mn-m-n)$ double tangents, it will be of the order $2mn\,(m+n-1)$.

When the curves $\mathfrak{A}$ and $\mathfrak{B}$ are conics, the curve $\mathfrak{C}$ is therefore of the class 8, with 16 double tangents but no inflexions, consequently of the order 24. But there are two remarkable cases in which the order is further diminished. First, when each of the conics $\mathfrak{A}$, $\mathfrak{B}$ has double contact with the conic $\mathfrak{S}$. The four points of contact give rise to 8 new double tangents, or there are in all 24 double tangents, the curve $\mathfrak{C}$ is therefore of the degree 8; and being of the class 8, with 24 double tangents, it must of necessity break up into four curves each of the class 2, *i. e.* into four conics. Each of these has double contact with the conic $\mathfrak{S}$, or attending only to one of the four conics, we have the well-known theorem, which I call the porism (homographic) of the in-and-circumscribed triangle, viz. "there are an infinity of triangles inscribed in a conic, and such that the sides touch conics having each of them double contact with the circumscribed conic."

Secondly, the conics $\mathfrak{A}$ and $\mathfrak{B}$ may intersect the conic $\mathfrak{S}$ in the same four points. Here every tangent of the curve $\mathfrak{C}$ is in fact a double tangent belonging to the first mentioned group, the curve $\mathfrak{C}$ in fact consists of two coincident curves; each of them therefore of the class 4. But this curve of the class 4 has itself four double tangents, arising from the common points of intersection of the conics $\mathfrak{A}$, $\mathfrak{B}$ with the conic $\mathfrak{S}$; it must therefore break up into two curves, each of the class 2, *i. e.* into two conics; each of these intersects the conic $\mathfrak{S}$ in the same four points in which it is intersected by the conics $\mathfrak{A}$, $\mathfrak{B}$. Attending only to one of the two conics, we have the other well-

known theorem, which I call the porism (allographic) of the in-and-circumscribed triangle, viz. "there are an infinity of triangles inscribed in a conic, and such that the sides touch conics, each of them meeting the circumscribed conic in the same four points."

The investigations, the results of which have just been stated, will appear in the Quarterly Mathematical Journal.

A Tract on the possible and impossible cases of Quadratic Duplicate Equalities in the Diophantine Analysis. By MATTHEW COLLINS, *B.A., Senior Moderator in Mathematics and Physics, and Bishop Law's Mathematical Prizeman, Trinity College, Dublin.*

The author of this tract divides it into three chapters.

Chapter I. treats of the possible and impossible cases of the two simultaneous equations $x^2+Ay^2=\square$ and $x^2-Ay^2=\square$; now it is *proved* in the original paper from which the present abstract is taken that this is impossible when A is any integer <20, except 5, 6, 7, 13, 14 or 15. And the *demonstrations of the impossibility* are extremely easy, clear, and rigorous, and possess the great advantage of being effected, in all the different cases, by one uniform method. This first chapter terminates with a *general* demonstration of the impossibility whenever A is a prime number, and such that neither m^2+1 nor m^2-2 is divisible by A, m being $<\frac{1}{2}$A.

In the cases that are possible, as many solutions as we please, in integers (x, y) prime to each other, are obtained in this paper with singular facility and rapidity by means of the following *new* and *useful*—

General Theorem.—The solution of $X^2+abY^2=\square=Z^2$ and $X^2-abY^2=\square=W^2$ can be obtained from a solution of the two *auxiliary equations* $ax^2+by^2=nz^2$ and $abx^2-y^2=\pm nw^2$, for in fact $X=\frac{1}{2}n(z^4+w^4)$ and $Y=2xyzw$ will answer.

Demonstration.—The difference of the squares of the two auxiliary equations gives $4abx^2y^2=n^2(z^4-w^4)$, and $\therefore abY^2=4abx^2y^2z^2w^2$, $\therefore =n^2z^2w^2(z^4-w^4)$; and as $4X^2=n^2(z^4+w^4)^2=n^2(z^4-w^4)^2+n^2(2z^2w^2)^2=n^2(t^2+v^2)$, where $t=z^4-w^4$ and $v=2z^2w^2$ and $4abY^2$ is $=4n^2z^2w^2(z^4-w^4)$, $\therefore =n^2(2tv)$,

$$\therefore 4(X^2\pm abY^2)=n^2(t\pm v)^2, \text{ which are both squares. Q. E. D.}$$

By taking $n=1$ and also $b=1$, we can, from one solution of the equations $x^2+ay^2=z^2$ and $x^2-ay^2=w^2$, derive another solution of the same equations in larger integers; thus new $X=\frac{1}{2}(z^4+w^4)$ and new $Y=2xyzw$.

Ex. gr. When $A=5$, then the *auxiliary* equations $x^2+5y^2=nz^2$ and $x^2-5y^2=-nw^2$ are obviously fulfilled by taking $n=1=y=w$, $x=2$ and $z=3$; hence by the general theorem, we find $X=\frac{1}{2}(z^4+w^4)=\frac{1}{2}(3^4+1^4)=41$ and $Y=2xyzw=12$ to fulfil the *proposed* equations

$$x^2+5y^2=\square=z^2 \text{ and } x^2-5y^2=\square=w^2,$$

giving $z=49$ and $w=31$; and from this set of answers we can, according to the above observation, deduce another set in larger integers; in fact, it is evident *new*

$$x=\tfrac{1}{2}(49^4+31^4)=3344161, \text{ and } new\ y=2\times 41\times 12\times 49\times 31=1494696,$$

from which we could again find new and very high values of x and y, and thus ascend into very great whole numbers.

When $A=6$, then $x=5$ and $y=2$ give $z=7$ and $w=1$;

$$\therefore new\ x=\tfrac{1}{2}(7^4+1^4)=1201,$$

and new $y=10\times 2\times 7=140$, giving *new* $z=1249$ and *new* $w=1151$, and thence again

$$New\ x=\tfrac{1}{2}(1249^4+1151^4) \text{ and } new\ y=1201\times 280\times 1249\times 1151, \text{ \&c.}$$

When $A=7$, then taking $n=2$, one obvious solution of the *auxiliary* equations $x^2+7y^2=2z^2$ and $x^2-7y^2=2w^2$ is $x=5$, $y=1$, $z=4$, and $w=3$; and hence by the above general theorem, we find $X=\frac{1}{2}n(z^4+w^4)=4^4+3^4=337$ and $Y=2xyzw=120$ to fulfil the two *proposed* equations $x^2+7y^2=\square=z^2$ and $x^2-7y^2=\square=w^2$, giving $z=463$ and $w=113$; and thence we find again, according to the above observation, *new* $x=\frac{1}{2}(463^4+113^4)$ and

$$new\ y=337\times 240\times 463\times 113,$$

from which we could again find values of x and y in integers still larger, &c.

When $A=13$, then taking $n=1$, one obvious solution of the *auxiliary* equations $x^2+13y^2=z^2$ and $x^2-13y^2=-w^2$ is $x=6$, $y=5$, giving $z=19$ and $w=17$; and hence by the *general theorem*, we find $X=\frac{1}{2}(19^4+17^4)=106921$ and $Y=10\times 6\times 19\times 17=19380$ to fulfil the two *proposed* equations, $x^2+13y^2=\square=z^2$ and $x^2-13y^2=\square=w^2$. These values of x and y give $z=127729$ and $w=80929$, from which again we find, according to the foregoing observation, *new* $x=\frac{1}{2}(127729^4+80929^4)$ and

$$new\ y=2\times 106921\times 19380\times 127729\times 80929, \text{ \&c.}$$

Finally, it is observed that the solution of $X^2+ab\,Y^2=\square=Z^2$ and $X^2-abY^2=\square=W^2$ can be also derived from a solution of the *auxiliary* equations $x^2+y^2=az^2$ and $x^2-y^2=bw^2$, since in fact $X=x^4+y^4$ and $Y=2xyzw$ will answer; for then

$$abY^2=4abx^2y^2z^2w^2=4x^2y^2(az^2)(bw^2)=4x^2y^2(x^4-y^4)=2tv$$

where $t=x^4-y^4$ and $v=2x^2y^2$, and $X^2=(x^4+y^4)^2=t^2+v^2$; and so

$X^2\pm abY^2=(t\pm v)^2$, which are both squares. Q. E. D.

Chapter II. treats of the possible and impossible cases of the two simultaneous equations $x^2+y^2=\square$ and $x^2+Ay^2=\square$. Now in the original paper it is rigorously *demonstrated* by one uniform, easy, and satisfactory method, that this is *impossible* when A is any positive integer <20, except 7, 10, 11 or 17; and it is also satisfactorily proved that the proposed equations will be always *possible* or solvable whenever A is $=2a^2-8$, or $2a^2-1$, or $2a^2+2$, or $2a^2+9$, or $2a^2+50$, or $3a^2-48$, or $3a^2-3$, or $3a^2+4$, or $3a^2+49$, or $5a^2-4$, or $5a^2+5$, or $5a^2-80$, or $5a^2+81$, or $6a^2-2$, or $6a^2+3$, or $4a^2\pm 3a$, or $\frac{5a^2}{4}$, diminished either by $\frac{1}{4}$ or by $1\frac{1}{4}$, &c. &c. And thus the proposed equations will be possible or soluble whenever A is any of the following integers; viz. 7, 10, 11, 17, 20, 22, 24, 27, 30, 31, 34, 41, 42, 45, 49, 50, 52, 57, 58, 59, 60, 61, 68, 71, 72, 74, 76, 79, 82, 85, 86, 90, 92, 94, 97, 99, 100, 101, 104, 105, 112, 115, 119, 120, 121, 122, &c.

The solutions of the possible cases are inferred with great facility in the present paper from the following *new* and *useful*—

General Theorem.—The values of X and Y in $X^2+Y^2=\square=Z^2$ and $X^2+abY^2=\square=W^2$ can be deduced or inferred from the values of x and y in the *auxiliary equations* $x^2+ay^2=nz^2$ and $y^2+bx^2=nw^2$; in fact, $X=x^2w^2-y^2z^2$ and $Y=2xyzw$ will answer; for then $X^2+Y^2=(x^2w^2+y^2z^2)^2$. And so the first condition is fulfilled. Now $nX=x^2(y^2+bx^2)-y^2(x^2+ay^2)$, $\therefore =bx^4-ay^4$; also $n^2Y^2=4x^2y^2(x^2+ay^2)(y^2+bx^2)$, $\therefore =4x^4y^4(1+ab)+4bx^6y^2+4ax^2y^6$; and so $n^2(X^2+abY^2)=(bx^4+2abx^2y^2+ay^4)^2$; and hence

$$X^2+abY^2=(bx^4+2abx^2y^2+ay^4)^2\div n^2,\ \therefore =\square.$$

And thus these values of X and Y satisfy the second condition also. Q. E. D.

If a or b be negative, we obtain a solution of $X^2+Y^2=\square$ and $X^2-abY^2=\square$; but by taking $b=1$ and $n=1$, and interchanging z and w, this general theorem shows that, "from one solution of the proposed equations $x^2+y^2=z^2$ and

$x^2+Ay^2=w^2$ we can obtain another solution of the same equations, in larger integers, by only taking new $X=Ay^4-x^4$ and new $Y=2xyzw$." We shall give here only a few instances of the use of this *most important* theorem.

When $A=7$, then the proposed equations $x^2+y^2=\square=z^2$ and $x^2+7y^2=\square=w^2$ are obviously fulfilled by $x=3$, $y=4$, $z=5$, and $w=11$; whence for a second solution we have only to take new $x=7\times4^4-3^4=1711$ and new $y=2xyzw=1320$, giving $\therefore$ new $z=2161$ and new $w=3889$; and thence again a third set of answers are new $x=7\times1320^4-1711^4$ and

$$new\ y=2\times1711\times1320\times2161\times3889.$$

When $A=10$, one solution is obviously $x=3$ and $y=4$, from which new solutions can be obtained as above. When $A=11$, then taking $n=5$, a possible remainder of squares to modulus 11, the *auxiliary* equations $x^2+y^2=5z^2$ and $x^2+11y^2=5w^2$ are obviously fulfilled by $x=1$, $y=2$, $z=1$, and $w=3$; whence by our general theorem we have $X=x^2z^2-y^2w^2=35$ and $Y=2xyzw=12$, which are the *least* values of x and y to answer the *proposed* equations $x^2+y^2=\square=z^2$ and $x^2+11y^2=\square=w^2$, giving $z=37$ and $w=53$; and thence again another set of answers are new $x=11y^4-x^4$, $\therefore=1272529$ and new $y=2xyzw=70\times12\times37\times53=1647240$, and thence again new $X=11y^4-x^4=11\times1647240^4-1272529^4$, &c.

When $A=4$, the proposed equations ($x^2+y^2=\square$ and $x^2+4y^2=\square$) are proved to be impossible, whence by taking $a=b=-2$ and $n=-1$, it follows from the foregoing general theorem that the *auxiliary* equations $2y^2-x^2=z^2$ and $2x^2-y^2=w^2$ must be also impossible, *i. e.* there cannot be four square numbers, w^2, x^2, y^2, z^2, in arithmetical progression.

Chapter III. treats of the possible and impossible cases of the two simultaneous equations $x^2-y^2=\square$ and $x^2-Ay^2=\square$. In the paper, of which we here present a very short abstract, this is rigorously demonstrated to be *impossible* when A is any integer <13, except 7 or 11; the solutions of the *possible* cases in integers x, y prime to each other are obtained with great facility and generality from the following *new* and *important*—

General Theorem.—The values of X and Y to fulfil $X^2-Y^2=\square=Z^2$ and $X^2-abY^2=\square=W^2$ can be got from the solution of the *auxiliary* equations $x^2-ay^2=nz^2$ and $bx^2-y^2=nw^2$, since in fact $X=x^2w^2+y^2z^2$ and $Y=2xyzw$ will answer the purpose, as is easily demonstrated.

By taking $b=1$, and interchanging z and w in this general theorem, we see that the solution of $X^2-Y^2=Z^2$ and $X^2-aY^2=W^2$ can be obtained from the solution of $x^2-y^2=nz^2$ and $x^2-ay^2=nw^2$ merely by taking $X=x^2z^2+y^2w^2$ and $Y=2xyzw$. And then again, by taking $n=1$, this general theorem shows how to find a solution in great integers from a known solution in smaller integers of $x^2-y^2=z^2$ and $x^2-ay^2=w^2$; for *then* new $X=x^2z^2+y^2w^2=x^4-ay^4$ and new $Y=2xyzw$ in *all* cases.

Ex. gr. Let $a=7$, so that the two equations to be solved are $x^2-y^2=\square=z^2$ and $x^2-7y^2=\square=w^2$; then taking $n=2$, a possible remainder of square numbers to divisor 7, we see that one obvious solution of the two *auxiliary* equations $x^2-y^2=2z^2$ and $x^2-7y^2=2w^2$ is $x=3$, $y=1$, $z=2$, and $w=1$; and $\therefore$ by the foregoing $X=x^2z^2+y^2w^2=37$ and $y=2xyzw=12$, which are the *least integers* to answer the two proposed equations; they give $z=35$ and $w=19$; and from this solution we find another, as indicated above, viz. *new* $X=x^4-ay^4=37^4-7\,.\,12^4=1729009$ and new

$$Y=2xyzw=37\times24\times35\times19=590520.$$

And now using these values of X and Y for x and y, we thence get another solution by the same formulæ, viz.

$$new\ X=x^4-ay^4=1729009^4-7\ .\ 590520^4=\&c.$$

As another example, let $a=11$, so that the two equations to be solved are $x^2-y^2=\square=z^2$ and $x^2-11y^2=\square=w^2$; then taking $n=5$, we see that one obvious solution of the two *auxiliary* equations $x^2-y^2=5z^2$ and $x^2-11y^2=5w^2$ is $x=7$, $y=2$, $z=3$, and $w=1$; and $\therefore$ by the foregoing theorem

$$X=x^2z^2+y^2w^2=21^2+2^2=445 \text{ and } Y=2xyzw=84,$$

which are the least *integral* values of x and y to fulfil the *proposed* equations; they give $z=437$ and $w=347$; and now from this solution we find another, as indicated above, viz. *new* $X=x^4-ay^4=445^4-11 \,.\, 84^4$ and

$$\textit{new } Y=2xyzw=2\times445\times84\times437\times347=\&c.;$$

and by using these values of X and Y for x and y, we can thence again find X and Y in very great integers, &c. By taking a negative, we could obviously deduce the solution of $X^2-Y^2=Z^2$ and $X^2+abY^2=W^2$ from a solution of the two *auxiliary* equations $x^2+ay^2=xz^2$ and $bx^2-y^2=nw^2$. Finally, we may observe that the two equations $x^2-y^2=\square$ and $x^2-Ay^2=\square$ will be simultaneously *possible* whenever A is $=9-2a^2$, or $50-2a^2$, or $49-3a^2$, or $81-5a^2$, or $25-6a^2$, or $64-7a^2$, or $100-11a^2$, or any of the following integers, viz. 7, 11, 18, 19, 22, 32, 36, 37, 42, 46, 48, 56, 57, 61, &c.

General Theorem.—The solution of $X^2+Y^2=\square$ and $X^2+(a+1)Y^2=\square$ can be obtained from a solution of the two *auxiliary* equations $x^2\pm y^2=nz^2$ and $ay^2\mp x^2=nw^2$; in fact $X=x^2z^2-y^2w^2$ and $Y=2xyzw$ will answer, as is easily demonstrated.

Another General Theorem.—The solution of $X^2-Y^2=\square$ and $X^2-(a+1)Y^2=\square$ can also be obtained from a solution of the two *auxiliary* equations

$$\left\{\begin{array}{l} x^2-y^2=nz^2 \\ ax^2+y^2=nw^2 \end{array}\right\},$$

or from a solution of the pair

$$\left\{\begin{array}{l} y^2+\ x^2=nz^2 \\ y^2-ax^2=nw^2 \end{array}\right\};$$

for in fact $X=x^2w^2+y^2z^2$ and $Y=2xyzw$ will answer, as is also easily demonstrated.

The author states, that it is the demonstrations of the *impossible* cases that have led to the discovery of *all* the foregoing general theorems for solving the possible cases; and although these demonstrations of the impossible cases are *by far* the most *interesting and valuable part* of this Tract, they are necessarily, on account of their length, omitted in the present abstract; but the Tract quite entire will be soon published.

On a more general Theory of Analytical Geometry, including the Cartesian as a particular case. By Alexander J. Ellis, *B.A., F.C.P.S.*

Assuming a Roman i as the symbol for rotating through 90°, it is shown that $(x+\mathrm{i})(x-\mathrm{i})=x^2+1$, and that therefore $\mathrm{i}=\sqrt{(-1)}$. Taking $(p+\mathrm{i}q)\mathrm{L}$ as the representative of a line of the length $\sqrt{(p^2+q^2)}\,.\,\mathrm{L}$, L being the unit of length, making an angle θ with the axis, where $\sqrt{p^2+q^2}.\sin\theta=q$ and $\sqrt{p^2+q^2}.\cos\theta=p$, this line will determine its extreme point when referred to a known origin, axis, and scale.

Two Dimensions.

Simple Locus.—If q be a function of p, then the *two* expressions $p+\mathrm{i}q$ and $q=q_p$ determine a curve. This corresponds with the usual Cartesian case.

General Locus.—If $x=p+iq$ and $y=r+is$, and $f(x, y)$ be any function of x and y, then $f(x, y)=X+iY$, where X and Y are functions of p, q, r, s, which determines a point. If, moreover, we have given $q=q_p$ in order to have only *one* variable p, and also $\phi(x, y)=\phi'(p, q, r, s)+i\phi''(p, q, r, s)=0$ as any relation between x and y, then the whole system $f(x, y)$, $q=q_p$, and $\phi(x, y)=0$ determines a curve, called the general locus, which is found by eliminating p, q, r, s between the five equations X and Y= functions of p, q, r, s, $q=q_p$, $\phi'=0$, and $\phi''=0$, whence Y = a function of X, and the required locus is the simple locus of X+iY and Y= function of X.

Particular cases.—If $q=s=0$, and first, $f(x, y)=p+ir$, we have a case corresponding to the Cartesian rectangular coordinates. If, secondly, $f(x, y)=p(\cos\alpha+i\sin\alpha)+r(\cos\beta+i\sin\beta)$, we have the case of oblique coordinates; while, thirdly, $f(x, y,)=r(\cos p+i\sin p)$ gives the case of polar coordinates.

Radical Loci of the equation $\phi(x, y)=0$ for $q=q_p$. From $q=q_p$, $\phi'=0$, $\phi''=0$, find $s=s_r$ and $r=r_p$, and describe the simple loci of—

1. $p+iq$ and $q=q_p$ giving x from p,
2. $r+is$ and $s=s$ giving y from r, while
3. $p+ir$ and $r=r_p$ gives r from p;

so that by setting off pL, both xL and yL are found. In the Cartesian case, $q=s=0$ and the loci 1. and 2. coincide with the axis, while 3. is the ordinary locus.

Three Dimensions.

Assume a known origin, axis, scale, and plane, called the cumbent plane. On this plane draw a line determined by $p+iq$. Through this line draw a plane perpendicular to the former, called the *sistent* plane. On this set off rL, where $r=$ some function of p and q, in the direction of the line already determined, and then set off the line determined by $r+is$ on the sistent plane. The extremity of this second line determines any point in space.

Simple Locus.—If p and q are independent, and $s=$ a function of r, and therefore of p and q, the points determined by $p+iq$ and $r+is$ lie on a surface. If, in addition, q (and therefore r and s) be a function of p, the points determined by the system lie on a curve.

General Locus.—If $x=p+iq$, $y=r+is$, and $z=u+iv$, then $f(x, y)$ will determine a line on the cumbent plane, and $f'(p, q, r, s, z)$ a line on the sistent plane drawn through the former. Assuming q a function of p and s a function of r in order to have only two variables, and $\phi(x, y, z)=0$ as any relation between x, y, z, then finding $f(x, y)=X+iY$ and $f'(p, q, r, s, z)=R+iZ$, with $\phi(x, y, z)=\phi'+i\phi''=0$, where X, Y, Z, R, ϕ', ϕ'' are all functions of p, q, r, s, u, v, or by virtue of the relations between q and p, s and r, functions of p, r, u, v *only*, we find from $\phi'=0$ and $\phi''=0$ that u and v, and hence X, Y, Z, R, are functions of p and r only. Hence by two eliminations R and Z are found as functions of X and Y. The general locus is then the simple locus of X+iY on the cumbent, and R+iZ on the sistent planes, where R and Z are known functions of X and Y.

Particular cases.—Taking $q=s=v=0$, and assuming R so that RL is always the length of the line determined by $f(x, y)$, we readily obtain cases corresponding to the Cartesian rectangular oblique and polar coordinates.

Radical Loci of $\phi(x, y, z)=0$ for q a function of p, and s of r. Having found u and v functions of p and r as before, describe the simple loci of—

1. $p+iq$ and $q=$ function of p; and 2. $r+is$ and $s=$ function of r, both on the cumbent plane, to find x and y.

3. $p+ir$ on the cumbent, and $\sqrt{(p^2+r^2)}+iv$ on the sistent plane, with v a function of p and r, giving a surface, whence ivL is found on the sistent, and therefore also on the cumbent plane.

4. $p+ir$ on the cumbent, and $\sqrt{(p^2+r^2)}+iu$ on the sistent plane, with u a function of p and r, giving a surface, whence iuL is found on the sistent, and therefore also uL on the cumbent plane.

Hence $(u+iv)\mathrm{L}=z\mathrm{L}$ is also found on the cumbent plane, and x, y, z can be fully represented for any values of p and r.

By this theory, all cases of impossible roots of equations with one, two, or three unknown expressions admit of geometrical representation, while every Cartesian case is included.

On the conception of the Anharmonic Quaternion, and on its application to the Theory of Involution in Space. By Sir W. R. HAMILTON, *LL.D.*

LIGHT, HEAT, ELECTRICITY, MAGNETISM.

On the Fixing of Photographs. By Dr. ADAMSON.

On the Triple Spectrum. By Sir DAVID BREWSTER, *K.H., F.R.S. L. & E.*

At an early meeting of the Association the author communicated to the Association an account of the experiments by which he endeavoured to establish the existence of a triple spectrum, that is, a spectrum which, instead of consisting of seven different colours, consisted of three spectra of equal length—red, yellow, and blue—having different degrees of intensity in different parts, and their ordinates of maximum intensely incoincident. This paper, entitled "A new Analysis of Solar Light," was published in 1831 in the Transactions of the Royal Society of Edinburgh. The experiments were shown to some of the distinguished members of that body, who honoured them by the adjudication of the Keith Medal. To objections which have been raised by Mr. Airy, Dr. Draper and M. Melloni to the accuracy of these results, the author has replied successively, and, he has reason to think, successfully.

Within the last few years the subject of the triple spectrum has been studied by two eminent individuals, M. Bernard in France, and M. Helmholtz in Prussia, both of whom have called in question the accuracy of his conclusions. To the observations of these two writers he did not think it necessary to reply; but being obliged to refer to the subject of the changes of colour produced by absorption, and consequently to the triple spectrum, in his History of Newton's optical discoveries, he found it necessary to notice the objections which had been made to it; and he now submitted to the Section a few of the remarks which he has there made upon the experiments of these two foreign observers.

To make these remarks intelligible, he first stated that his analysis of the spectrum embraces three propositions, which to a certain extent are independent of each other:—

1. That the colours of the spectrum may be changed by absorbing media acting by reflexions and transmissions.

2. That in pure spectra white light, which the prism cannot decompose, can be insulated; and

3. That the Newtonian spectrum of seven colours consists of three equal primary spectra—red, yellow, and blue superposed,—having their maximum intensity of illumination at different points, and shading to nothing at their extremities.

"Now," observes the author, "the first of these propositions may be true, even though we could not insulate white light at any point of the spectrum; and both the first and second may be true, without our being able to demonstrate that the three spectra have the same length, and diminish in intensity from their maxima of

illumination to their extremities. The general proposition, that the colours of the spectrum are changed by absorption, was denied, as already stated, by Mr. Airy, and by Dr. Draper and M. Melloni, whereas both M. Helmholtz and M. Bernard have admitted it as an indubitable truth. In direct contradiction of Mr. Airy's statement, M. Helmholtz has candidly remarked, 'that the changes of colour which Sir D. Brewster described, as produced by absorption, are for the most part sufficiently striking to be observed without difficulty;' and he adds, 'that a careful repetition of at least the most important of the experiments, carried out in exact accordance with the method laid down, and with every precaution taken, has, indeed, taught him that the facts are described with perfect accuracy.' In these words, which are those of M. Helmholtz himself, the change of colour is admitted as a physical fact; but he ascribes it to two causes:—1, to the possible admixture of rays scattered from the prism, and the other transparent bodies used in the experiment; and 2, to the mixture of complementary colours, produced by the action of the other colours of the spectrum on the retina."

The author remarks, that the first of these causes, namely, the possible admixture of scattered rays, is a very extraordinary one, and that it should not have been assumed without some attempt to show its probability. He observes, "it is certainly possible that scattered rays may have influenced my retina; but, even if such rays did exist, it would be necessary to show that they were the precise rays which were capable of producing the alleged change of colour. Now M. Helmholtz has not even attempted to make it probable that such disturbing rays exist or could have influenced any retina if they did exist; nor has he attempted to show that such possible rays are of colours which are complementary to those which I saw. With regard to the second cause, namely, the admixture of complementary colours, I unhesitatingly deny that it had any influence in the phænomena which I observed; and I earnestly request the attention of the Section to the following observations:—If the subjective perception of colour, when we view the spectrum or make experiments, in which more than one colour reaches the eye, is capable of altering the colours under examination, then all that has been written on colours, thus seen, must be erroneous, and all the gay tints of Art or of Nature, which we admire and study, are but false hues under the metamorphosis of a subjective perception. We must not now pronounce a rose to be red and its leaves green till we have stared at them through a chink or torn them from their footstalk. The changes of colour by absorption which I have described I have distinctly seen, and seen as correctly as Newton saw his seven colours in the spectrum, and Hooke his composite tints in the soap-bubble; and, now that my eyes have nearly finished their work, I cannot mistrust, without reason, such good and faithful servants.

"The observations of M. Bernard, who has repeated only a few of my experiments, differ very little in their character from those of M. Helmholtz. He maintains that the conversion of the blue space into violet, which I observed, arises from the diminution of the light by absorption. Now, if the colours of the spectrum thus change when they become fainter, we would desire to know at what degree of illumination we are to see the prismatic spectrum in its true colours. If the blue space is converted into violet by the diminution of its light, then colour does not depend upon refrangibility alone, but also upon intensity of illumination; a doctrine as subversive as mine of the opinion of Newton, that to the same refrangibility always belongs the same colour. If M. Bernard's experiments be correct, it is perfectly compatible with my opinion, because it only proves that the blue rays, when enfeebled, lose their power over the retina sooner than the red. Nay, it is a sound argument in favour of the doctrine which it is brought forward to disprove."

In concluding his communication, the author mentions that none of the opponents of the triple spectrum have repeated his fundamental experiment made with an apparatus which he believes no person but himself possesses. He examines a pure spectrum divided into compartments by the action of thin plates of calcareous spar passing across a prism of the same substance. Each of these luminous compartments shades off into the adjacent dark spaces, and is in a different condition from the corresponding portion of the complete spectrum. When the proper absorbing media are applied to certain portions of this divided spectrum, he insulates a large portion of white light indecomposable by the prism, and it stands beside a

portion of red light as distinctly as an almond placed beside a cherry. This is an *experimentum crucis*, if one were wanting in favour of the doctrine of a triple spectrum,—of the existence of three colours, red, yellow, and blue at the same point of the spectrum.

On the Binocular Vision of Surfaces of Different Colours. By Sir David Brewster, *K.H., F.R.S. L. & E.*

Prof. Dove had published an account of some beautiful experiments in connexion with this subject some years ago. M. Dove showed in his paper, that when different colours at the same real distance are regarded by the eye, they appear to be at different distances; this is also the case when a white surface is compared with a black. Now M. Dove argues if a white surface and a black one be stereoscopically combined, one of them must be seen through the other. Taking a figure for the left eye with a white ground, and a second figure of the same object on a black ground for the right eye, when these two figures are combined, a beautiful effect is observed; the figure starts into relief, and its sides appear to possess a shining metallic lustre. This is the case when the surface of each single object is quite dull and without lustre. On this experiment M. Dove founds a theory of lustre, supposing it to be produced by the action of light received from surfaces at different distances from the eye. An example of this is the effect observed on looking at varnished pictures: one portion of the light comes from the anterior surface of the varnish and the other from its posterior surface, the action of both of these conspiring to produce the observed lustre. The metallic lustre of mica is also referred to by M. Dove as an example of the same kind. In his present communication, Sir David Brewster controverts the theory here laid down, and bases his objections on the following remarkable experiment:—where a white surface without definite boundary and a black surface of the same kind are regarded through the stereoscope, no lustre is observed. Sir David therefore infers that the lustre is due, not to the rays from one surface passing through the other to the eye, but to the effort of the eyes to combine the two stereoscopic pictures.

On the Existence of Acari in Mica. By Sir David Brewster, *K.H., F.R.S.*

While examining with a microscope a thick plate of mica from Siberia, about 5 inches long and 3 inches wide, Sir David was surprised to observe the remains of minute animals, some the 70th of an inch, and others only the 150th of an inch in size. Some of these were enclosed in cavities, round which the films of mica were in optical contact. These acari were, of course, not fossil, but must have insinuated themselves through openings between the plates of mica, which afterwards closed over them.

On the Absorption of Matter by the Surfaces of Bodies. By Sir David Brewster, *K.H., F.R.S. L. & E.*

If we smear, very slightly, with soap the surface of a piece of glass, whether artificially polished or fused, and then clean it perfectly with a piece of chamois leather, the surface, when breathed upon, will exhibit, in the most brilliant manner, all the colours of thin plates. If we breathe through a tube, the colours will be arranged in rings, the outermost of which is black, corresponding to the centre of the system of rings formed between a convex and a plane surface of glass. In repeating this experiment on the surfaces of other bodies, Sir David found that there were several on whose surfaces no colours were produced. Quartz exhibited the colours like glass, but calcareous spar and several other minerals did not. In explaining this phænomenon, the author stated that the particles of the soap, which are dissolved by the breath, must either enter the pores of the bodies or form a strongly adhering film on their surface. This property of appropriating temporarily the particles of soap, becomes a new distinctive character of mineral and other bodies.

On the Remains of Plants in Calcareous Spar from King's County, Ireland. By Sir David Brewster, *K.H., F.R.S. L. & E.*

On the Phænomena of Decomposed Glass.
By Sir David Brewster, *K.H., F.R.S. L. & E.*

These papers were illustrated by elaborate drawings of the phænomena.

On the Making and Magnetizing of Steel Magnets.
By Paul Cameron, *Glasgow.*

The author records a few experiments in the forging, softening, hardening, and magnetizing of them. He procured one dozen of magnets: four of them were forged, hardened, and magnetized north and south; four were forged, hardened, and magnetized N.E.; and the remaining four were forged, hardened, and magnetized east and west. One dozen compass needles were forged, hardened, and magnetized similar to the above; four of the compass needles were enclosed in an iron case filled with fresh lime; the case was then put into a fire until it became a deep red, and was then covered up and allowed to cool slowly. The needles were then dressed and hardened in a fire mixed with bone-dust, the bone-dust being mixed with charcoal and lime, which would further increase the quality of the steel.

The average magnetic powers of the magnet before magnetizing were as follows:—

The magnetic powers of the bars hardened	N. and S.	from 7° to 10.
... ...	N.E.	... 5° to 7°.
... ...	E. and W.	... 1° to 2°.

He then placed a large copper coil, having an inclination corresponding with the dip, in the magnetic meridian, and connected the coil with the poles of a galvanic battery containing thirty-six pairs of plates; passed and repassed the magnets that were hardened N. and S.; placed the coil in a N.E. direction, and passed and repassed the magnets hardened N.E.; and then placed the coil in the direction E. and W., and passed and repassed the magnets that were hardened E. and W.

The magnets hardened and magnetized	N. and S.,	average deflection from 43° to 45°.
... ...	N.E.	36° to 38°.
... ...	E. and W.	20° to 22°.

A similar result followed after the needles were passed through the coil.

On the Deviations of the Compass in Iron Ships and the means of adjusting them. *By* Paul Cameron.

On an Analogy between Heat and Electricity.
By the Rev. Professor Chevallier.

Arago, in his posthumous work on lightning (Œuvres de François Arago, Notices Scientifiques, tom. i. Paris, 1854), distinguishes three classes of lightning, of which the third is that which takes the form of a fire-ball.

He produces many examples (chap. vi. vii.), the principal facts being, that during a thunder-storm balls of fire are sometimes seen; that they sometimes move very slowly, not faster than a mouse (ch. vii. § 3), so that, in a room, a person may get out of their way (ch. vii. § 6), rolling over and over like a kitten, or may follow them for a considerable distance on foot (ch. vii. § 5); that for a time the presence of such a ball may produce no injurious effect; but that it usually explodes at last with prodigious violence.

It does not seem to have been pointed out, that this form of electricity bears a remarkable analogy to the spheroidal form which fluids assume when in apparent contact with bodies intensely heated. The attention of the Section was invited to the subject.

On the Polystereopticon. *By* Antoine Claudet, *F.R.S.*

On the Heat produced by the Influence of the Magnet upon Bodies in Motion. By M. Léon Foucault, *Paris.*

In 1824, Arago observed the remarkable fact of the attraction of the magnetic needle by conducting bodies in motion. The phænomenon appeared very singular, and remained without explanation until Faraday announced the important discovery of currents of induction. It was then evident, that in Arago's experiments the motion gave rise to currents, which, by reacting upon the magnet, tended to associate it with the moveable body and draw it in the same direction. It may be said, in general terms, that the magnet and the conducting body tend towards a state of relative repose by a mutual influence.

If, notwithstanding this influence, it is desired to continue the motion, a certain amount of force (*travail*) must be constantly furnished; the moveable part seems to be, as it were, pressed by a break, and this force which disappears necessarily produces a dynamic effect, which I have thought must be represented by heat.

We arrive at the same inference by taking into consideration the currents of induction which succeed one another in the interior of bodies in motion; but an idea of the quantity of heat produced would only be acquired with great difficulty by this mode of regarding the affair, whilst by considering this heat as due to a transformation of force, it appeared certain to me that a sensible elevation of temperature would be easily produced in a decisive experiment. Having ready to my hand all the elements necessary for a prompt verification, I proceeded to its execution in the following manner.

Between the poles of a strong electro-magnet I partially introduced the solid of revolution belonging to the apparatus which I have called a *gyroscope*, and which was previously employed in experiments of a very different nature. This solid is a torus of bronze connected by a toothed pinion with an apparatus of wheels, by the action of which, when turned by the hand, it may revolve with a rapidity of 150 or 200 turns in a second. To render the action of the magnet more effective, two pieces of soft iron added to the helices prolonged the magnetic poles, and concentrated them in the vicinity of the revolving body.

When the apparatus is going with the greatest rapidity, the current of six Bunsen's couples, passed into the electro-magnet, stops the movement in a few seconds, as though an invisible break had been applied to the moving body: this is Arago's experiment, as developed by Faraday. But if the handle be then pushed, so as to restore to the apparatus the movement which it has lost, the resistance experienced requires the application of a certain amount of force, the equivalent of which reappears and accumulates in heat in the interior of the revolving body.

By means of a thermometer inserted in the mass we may follow the gradual elevation of temperature. Having, for example, taken the apparatus at the surrounding temperature of 60°·8 F., I saw the thermometer rise successively to 68°, 77°, 86°, and 93°·2 F.; but the phænomenon had previously become sufficiently developed to render the employment of the thermometer unnecessary, as the heat produced had become sensible by the hand.

If the experiment appear worthy of interest, it would be easy to arrange an apparatus to reproduce and augment this phænomenon. There is no doubt, that by means of a machine properly constructed, and composed only of permanent magnets, high temperatures might be produced, so as to place before the eyes of the public assembled in lecture rooms a curious example of the conversion of force into heat.

On a Machine for Polishing Specula. By Dr. Green.

On the Optical Properties of Cadmacetite. By William Haidinger, *Vienna.*

[Crystals of the salt were laid before the Section by Sir David Brewster.]

I have the honour to lay before the Association a short notice on the Absorption of the Crystals of Acetate of Cadmium, or to denote them by a single word, of *Cadmacetite*, together with some of the crystals, which form the subject of the communication.

The form of the crystals belongs to the oblique system. The apparent longitudinal axis of the broad six-sided prisms makes an angle of nearly 100° with the base. There is a most perfect cleavage parallel to the axis in only one direction, which bisects the prism of 135° 39′. The plane of the optic axis is perpendicular to this plane of cleavage. One of the axes of elasticity makes with the plane of cleavage an angle of about 10°. If now the crystals are examined as to their polarization in a direction perpendicular to the plane of the optic axes, it will be found that the pencil polarized parallel to the above-mentioned axis, which makes the angle of 10° with the faces of cleavage, freely passes the crystal, but that the pencil polarized perpendicularly to it does not pass. It is true, there appears not exactly a black tint, but only a more or less dark gray; but the contrast nevertheless is very striking. On the mode of examination being reversed, the effect is still more powerful. A plate of cadmacetite cut perpendicular to the plane of cleavage, parallel to the axis of the crystals, when held near the eye, will extinguish one of the two images of a doubly refracting prism entirely, without letting pass a trace of light, if the plate be only so much as one-fourth of an inch in thickness.

It is the more unexpected to find such great contrasts in the modifying power of these crystals in respect to light, as for the rest they are perfectly colourless. M. Charles von Hauer has succeeded in obtaining crystals 3 inches long and 1 inch thick, but they are always very little homogeneous, consisting of concentric funnel-shaped portions, which makes it very difficult to extract larger portions fit for being turned to advantage as a polarizing apparatus. It is deserving of notice, that some particular very compact portions of the crystals do not possess that characteristic absorbing property.

On the Optical Illusions of the Atmospheric Lens. *By* Evan Hopkins, *C.E., F.G.S.*

An Account of some Experiments with a large Electro-Magnet. *By* J. P. Joule, *F.R.S.*

Prof. W. Thomson, in Mr. Joule's absence, brought the subject before the Section. The relation of the exciting force to the sustaining power of a magnet was the subject which it was the author's desire to examine, the laws arrived at being very divergent from those usually received. The soft iron made use of in this magnet was of such a nature, that, after magnetization by moderate currents, it always—probably on account of intense magnetization on some former occasion—retained a residual polarity which was always in the same direction. The magnet might be excited by a current which developed a polarity opposed to the residual one; but on the interruption of the current, the latter re-appeared. With high power, the lifting power fell short of being proportional to the square of the current; but with feeble excitation, Mr. Joule found the sustaining force to vary nearly as the fourth power of the current strength employed.

Photographs of the Hartwell Observatory, and of the Craig Telescope at Wandsworth, were exhibited and described by Dr. Lee.

On New Forms of Microscope, adapted for Physiological Demonstration. *By* M. Nachot.

Elucidations, by Facts and Experiments, of the Magnetism of Iron Ships and its Changes. *By* William Scoresby, *D.D., F.R.S.S. Lond. & Edin., Corresp. Mem. of Institute of France, &c. &c.*

The author first recapitulated, as the basis of his present communication, the theoretic principles—concerning the magnetism of iron ships and its changes, with the effects on the action of the compasses—which he had formerly brought before the British Association, and described more elaborately in his "Magnetical Inves-

tigations." Referring, more particularly, to his paper of last session *On the Loss of the Tayleur*, and to the principles on which the lines of magnetic force, and the equatorial, or neutral plane, are adjusted in correspondency with the earth's polar magnetic axis,—it followed, he showed, that the distribution of the magnetic lines externally should have special relation to the direction of the ship's head whilst building, and should therefore be easily predicted, proximately, for every particular case.

The views of Dr. Scoresby on these fundamental principles, as well as on the source of and changes in the more intense quality of magnetism, the *retentive*, in iron ships, had had very extensive and beautiful verifications in actual experiments, since the former meeting of the Association. As to the equatorial plane of no-attraction, illustrated by diagrams in "Magnetical Investigations," which were cut in wood in the year 1851,—experiments in 1854 and 1855, on five or six ships whilst yet on the stocks, had shown the most remarkable correspondency. Thus, in the case of the *Elizabeth Harrison*, at Liverpool, having her head about E.N.E., which Dr. Scoresby examined in October 1854,—the plane of no-attraction on the starboard side was found to lie 11 feet 6 inches *lower* than that on the port side, whilst the difference, previously calculated, according to theory, was 11 feet! In the case, again, of the *Fiery Cross*, of Glasgow, investigated at his request by Mr. James Napier, the lines of no-attraction on the two sides, with the ship's head S.W.erly, were found to be almost exactly in agreement with theory. Again, in the case of the *Elba* of Newcastle, built at Jarrow on Tyne, with her head only half a point from the magnetic meridian; as also of another ship built on the same spot, the magnetic lines were found in close analogy with those figured in the diagrams above referred to. Finally, in the case of the *Persia*, a large and splendid ship built by Messrs. Napier and Co., at Glasgow, the magnetic lines, as determined by Mr. James Napier, were found to have the like conformableness with theoretic deduction. One striking and beautiful exception—beautiful because anticipated on magnetic principles—was brought out in experiments made by Mr. Robert Newall, Mr. George Palmer, and Mr. James Napier. This apparent exception consisted in certain *irregularities* in the external lines of the magnetic plane,—sometimes shown in sudden limited deflections,—a circumstance plainly referable to particular accumulations of iron material within, such as of beam ends, stringers, bulk-heads, &c., which the author had noticed in his "Magnetical Investigations" as not unlikely to disturb the regularity of the magnetic lines. In this case, therefore, the observed exception to regularity served most convincingly to confirm the general rule.

Dr. Scoresby then proceeded to show how mechanical action, such as vibration, straining, or blows of the sea, on an iron ship, must modify or change the original magnetic lines, and *tend* (whatever the extent might practically be) to bring them into some measure of conformity with the terrestrial magnetic force as applied to the new direction of the ship's head.

One case of positive and demonstrable change in the magnetic lines of a new ship, the *Imperador*, built at Liverpool, Dr. Scoresby had experimentally determined; a change which had taken place (in exact conformity with his predictions) whilst the ship was being fitted out for sea. In this instance the lines of no-attraction on the two sides of the ship, which from her position on the stocks must have originally differed some 10 feet in level, were found to have changed to within about 20 inches of the same level. This showed, as the general experience of the adjusters of compasses and observant navigators also indicated, that much service at sea, and well knocking about on various courses, had the tendency to bring the original extreme and oblique magnetic lines into a *normal direction*,—approaching to a *horizontal* equatorial plane with lines of no-deviation running on both sides, nearly on the same level, from stem to stern, and a polar axis (in the centre of the ship) vertical to the keel. This tendency was elucidated by different striking facts of experience.

The author further explained, and illustrated by bold and descriptive drawings, several cases of sudden and remarkable compass-changes, dwelling particularly on that of the *Tayleur*, where a change of some points had taken place within two or three days, whilst contending against a heavy sea with her head in a reverse position from that on the stocks; and on that of the *Ottawa*, one of whose compasses

suddenly changed two points from a heavy blow of the sea on the ship; on that of another ship where a similar change took place on occasion of a collision; on that of the —— (name not mentioned) where the steering compass suddenly changed several points, and produced an error in the ship's position within 24 to 30 hours, which, measured on a track chart by the first officer, in his, Dr. Scoresby's, possession, was very nearly of the extent of the breadth of Ireland! These various compass-changes were plainly in accordance with the theoretic principles formerly published by the author, with the exception of the latter, as to which the requisite data for tracing the probable causes had not been furnished.

Of compass-changes from *strokes of lightning* (one of the cases also predicted), Dr. Scoresby adduced the instances of the *Bold Buccleuch* and another ship, where the compass suddenly went wrong to the extent of several points.

Having elucidated, rapidly, these various magnetic phænomena and others belonging to ships built of iron, and having given a variety of examples of great or considerable alterations in the compass-direction of ships proceeding into southern latitudes, the author recalled attention to his plan of a *compass aloft*, as affording, in the absence of azimuths or other guidance from celestial observations, a simple and effective mode of ascertaining the direction of the ship's course, and so, by comparison with the steering compass, knowing its errors and the proper correction to be made. This plan, he observed, when properly carried out, and a table of deviations, if requisite, obtained, he believed to be perfectly safe and reliable; and he had much satisfaction in being able to state that it had not only been extensively adopted by some of our first firms interested in the building and property of iron ships, but had received the particular sanction and commendation of Mr. Airy, Astronomer Royal, and Lieut. Maury, U.S. Navy; that is, as being recommended by both these gentlemen for adoption for determining safe compass guidance, or the correction of adjusted compasses whenever they might be found to be in error.

On the Achromatism of a Double Object-glass.
By Professor STOKES, *M.A., D.C.L., Sec.R.S.*

The general theory of the mode of rendering an object-glass achromatic by combining a flint-glass with a crown-glass lens, is well known. The achromatism is never perfect, on account of the irrationality of dispersion. The defect thence arising cannot possibly be obviated, except by altering the composition of the glass. It seemed worthy of consideration whether much improvement might not be effected in this direction; but the problem which the author proposed for consideration was only the following:—Given the kinds of glass to be employed, to find what ought to be done so as to produce the best effect; in other words, to determine the ratio of the focal lengths which gives the nearest approach to perfect achromatism. Two classes of methods may be employed for this purpose. In the one, compensations are effected by trial on a small scale; in the other, the refractive indices of each kind of glass are determined for certain well-defined objects in the spectrum, such for example as the principal fixed lines. The former has this disadvantage, that compensations on a small scale do not furnish so delicate a test as the performance of a large object-glass. The observation of refractive indices, on the other hand, admits of great precision; but it does not immediately appear what ought to be done with the refractive indices when they are obtained. After alluding to the method proposed by Fraunhofer for combining the refractive indices, which, however, as he himself remarked, did not lead to results in exact accordance with observation, the author proposed the following as the condition of nearest approach to achromatism:—that the point of the spectrum for which the focal length of the combination is a minimum shall be situated at the brightest part, namely, at about one-third of the interval D E from the fixed line D towards E. The refractive index of the flint-glass may be regarded as a function of the refractive index of the crown-glass, and may be expressed with sufficient accuracy by a series with three terms only. The three arbitrary constants may be determined by the values of three refractive indices determined for each kind of glass. The result is as follows:—Let μ_1, μ_2, μ_3 be the refractive indices for the crown-glass; μ_1', μ_2', μ_3' the same for the flint-glass; μ, μ' the refractive indices of the two glasses for any arbitrary ray; *m*

the value of μ for the point at which the focal length is to be made a minimum; r the ratio of $\Delta \mu'$ to $\Delta \mu$ to be employed in the ordinary formula for achromatism. Then having calculated numerically

$$r_{1,2} = \frac{\mu'_2 - \mu'_1}{\mu - \mu}, \qquad r_{2,3} = \frac{\mu'_3 - \mu'_2}{\mu_3 - \mu_2},$$

we shall have

$$r = r_{1,2} + \frac{2\,m - \mu_1 - \mu_2}{\mu_3 - \mu_1}\,(r_{2,3} - r_{1,2}).$$

For the value of m it will be sufficient to take

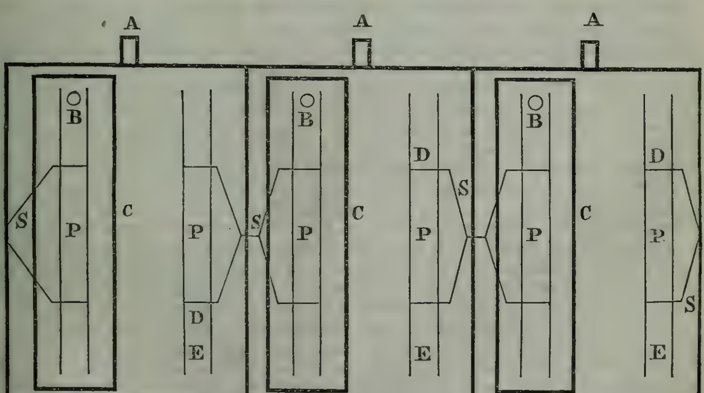
$$\mu_D + \frac{1}{3}\left(\mu_E - \mu_D\right).$$

On applying this formula to calculate r for the object-glass for which Fraunhofer has given both the refractive indices of the component glasses and the value of r, which, as observation showed, gave the best results, and taking in succession various combinations of three lines each out of the seven used by Fraunhofer, the author found that whenever the combination was judiciously chosen, the resulting value of r was the same, whatever might have been the combination, and equal to 1·980, which is precisely the value determined by Fraunhofer from observation, as giving the best effect.

On a new Form of the Gas Battery. By William Symons.

The ingenious and original arrangement known as Grove's gas battery, although always considered an instrument of great philosophical interest, appears to have been little used as an instrument of research and experiment, except in studying the combinations of different gases. The author has long thought that a modification of it may be usefully employed in many experiments requiring a weak but continuous current; and believes the following arrangement will be found convenient and economical. Fig. 1 is a plan, and fig. 2 a section of three pairs; the tray is made of gutta percha; it is divided into water-tight compartments about $2\frac{1}{2}$ inches wide; the length of the tray will of course depend on the number of cells required, and its width on the length of the strips of platinum; its depth about 1 inch. A are small tubes to keep the dilute acid at a uniform level; B are tubes perforated through the bottom of the tray, and standing above the level of the acid to admit a constant supply of

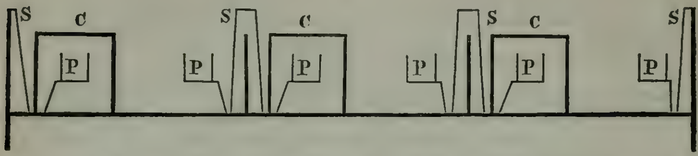
Fig. 1.



hydrogen from below; C are cells about 1 inch deep, $\frac{3}{4}$ inch broad, and long enough cover the platinum plates; these may be composed of glass, or gutta percha with

glass tops; P are the platinum plates, ½ inch wide, doubled lengthways into a U-shape, and divided in the middle through a part of their length; the connexions S

Fig. 2.



are silver wires passed through the platinum, and attached to it at D by the blowpipe without any solder. It would economize room to crease the platinum into short zigzags.

The battery, as here described, supposes the use of hydrogen and atmospheric air, but it may be easily modified for two gases without altering the cells or the plates, by the addition of tubes at E, similar to B, in communication with a supply of oxygen from below.

The advantages of this arrangement over Grove's are, cheapness of construction, the absence of connexions by mercury or binding screws, the facility for removing the plates to clean, &c., and the very great economy in the platinum; for whereas in Grove's battery a plate of 4 inches long and ½ inch broad would, according to his theory of its action, have but 1 inch of action, by the proposed arrangement it would have sixteen times that amount.

The author adds a suggestion with regard to apparatus of a totally different kind, such as condensers, multipliers, &c., used in static electricity, where a perfectly flat and smooth conducting surface is required; plate-glass gilded is generally used; the substitute he would propose is common slate; it is cheaper, stronger, and far more easily polished, shaped, and gilded; perhaps rubbing it over with good plumbago would render it a sufficiently perfect conductor; this is the plan adopted in an electroscope described in the 'Chemist' for August.

On certain curious Motions observable on the Surfaces of Wine and other Alcoholic Liquors. By James Thomson, *C.E., Belfast.*

The phænomena of capillary attraction in liquids (Mr. Thomson stated) are accounted for according to the generally received theory of Dr. Young, by the existence of forces equivalent to a tension of the surface of the liquid, uniform in all directions, and independent of the form of the surface. The tensile force is not the same in different liquids. Thus it is found to be much less in alcohol than in water. This fact affords an explanation of several very curious motions observable, under various circumstances, at the surfaces of alcoholic liquors. One part of these phænomena is, that if, in the middle of the surface of a glass of water, a small quantity of alcohol, or strong spirituous liquor, be gently introduced, a rapid rushing of the surface is found to occur outwards from the place where the spirit is introduced. It is made more apparent if fine powder be dusted on the surface of the water. Another part of the phænomena is, that if the sides of the vessel be wet with water above the general level surface of the water, and if the spirit be introduced in sufficient quantity in the middle of the vessel, or if it be introduced near the side, the fluid is even seen to ascend the inside of the glass until it accumulates in some places to such an extent that its weight preponderates, and it falls down again. The manner in which Mr. Thomson explains these two parts of the phænomena is, that the more watery portions of the entire surface, having more tension than those which are more alcoholic, drag the latter briskly away, sometimes even so as to form a horizontal ring of liquid high up round the interior of the vessel, and thicker than that by which the interior of the vessel was wet. Then the tendency is for the various parts of this ring or line to run together to those parts which happen to be most watery, and so there is no stable equilibrium, for the parts to which the various portions of the liquid

aggregate themselves soon become too heavy to be sustained, and so they fall down. The same mode of explanation, when carried a step further, shows the reason of the curious motions commonly observed in the film of wine adhering to the inside of a wine-glass, when the glass, having been partially filled with wine, has been shaken so as to wet the inside above the general level of the surface of the liquid; for, to explain these motions, it is only necessary further to bring under consideration, that the thin film adhering to the inside of the glass must very quickly become more watery than the rest on account of the evaporation of the alcohol contained in it being more rapid than the evaporation of the water. On this matter, Mr. Thomson exhibited to the Section a very decisive experiment. He showed that in a vial partly filled with wine, no motion of the kind described occcurs as long as the vial is kept corked. On his removing the cork, however, and withdrawing by a tube the air saturated with vapour of the wine, so that it was replaced by fresh air capable of producing evaporation, a liquid film was instantly seen as a horizontal ring creeping up the interior of the vial, with viscid-looking pendent streams descending from it like a fringe from a curtain. He gave another striking illustration by pouring water on a flat silver tray, previously carefully cleaned from any film which could hinder the water from thoroughly wetting the surface. The water was about one-tenth of an inch deep. Then, on a little alcohol being laid down in the middle of the tray, the water immediately rushed away from the middle, leaving a deep hollow there, which laid the tray bare of all liquid, except an exceedingly thin film. These and other experiments, which he made with fine lycopodium powder dusted on the surface of the water, into the middle of which he introduced alcohol gently from a fine tube, were very simple, and can easily be repeated. Certain curious return currents which he showed by means of the powder on the surface, he stated he had not yet been able fully to explain. He referred to very interesting phænomena previously observed by Mr. Varley, and described in the fiftieth volume of the Transactions of the Society of Arts, and he believed that many or all of these would prove to be explicable according to the principles he had now proposed.

On the Effects of Mechanical Strain on the Thermo-Electric Qualities of Metals. By Professor W. Thomson, *M.A., F.R.S.*

Having found by experiment that iron and copper wires, when stretched by forces insufficient to cause any permanent elongation, had their thermo-electric qualities altered, but immediately fell back to their primitive condition in this respect when the stretching forces were removed; having remarked that these temporary effects were in each case the reverse of the permanent thermo-electric effects previously discovered by Magnus, as resulting from permanent elongation of the wires, by drawing them through holes in a draw-plate; and thinking it most probable that all these effects depended on mechanical induction of the thermo-electric qualities of a crystal in the metals operated upon; the author undertook an experimental investigation of the thermo-electric effects of mechanical strains, in which he intended to include longitudinal extension, longitudinal compression, lateral compression, and lateral extension, and in each case to test both the temporary effects of strains within the elastic limits of the substance, and the residual alterations in thermo-electric quality, manifested after the cessation of the constraining force, when this has been so great as to give the substance a permanent set. The cycle of experiments has now been so nearly completed for both the temporary and the permanent strains, as to allow the author to conclude with certainty that the peculiar thermo-electric qualities induced in each case are those of a crystal. Thus, he finds that iron bars, hardened by longitudinal compression, have the reverse thermo-electric property to that discovered by Magnus in iron wires hardened by drawing; and that iron wire, under lateral compression, manifests the same thermo-electric property as the author had discovered in iron wire while under a longitudinal stretching force. The apparatus by which these results were obtained was exhibited to the Section, and the mode of experimenting fully described. As regards iron, the general conclusion is, that its thermo-electric quality, when under pressure in one direction, deviates from that of the unstrained metal, towards bismuth for currents in the direction of the strain, and towards antimony for currents perpendicular to

this direction; while for all cases that have been examined, the residual thermo-electric effect of a permanent strain is the reverse of the temporary thermo-electric effect which subsists as long as the constraining force is kept applied. Those of the other metals which have been as yet examined, namely, Copper, Lead, Cadmium, Tin, Zinc, Brass, *Steel*, and Platinum (specimens supplied as chemically pure by Messrs. Matthey and Johnson being in general used), showed uniformly the reverse effect to that of iron when similarly treated. The effects of permanent lateral compression by hammering were those which were chiefly tested for this list of metals, and were in almost every case of a very marked and unmistakeable kind. Curious results were also obtained by carefully annealing portions of wires which had been suddenly cooled, and leaving the remaining parts unannealed. Tin and Cadmium thus treated have, as yet, given only doubtful results; Platinum has not been tried; Iron, Steel, Copper, and Brass have given decided indications, in which the unannealed portions showed the same kind of thermo-electric effect as had been found to be produced by permanent lateral compression.

On the Use of Observations of Terrestrial Temperature for the investigation of Absolute Dates in Geology. By Professor W. THOMSON, *M.A., F.R.S.*

The relative thermal conductivities of different substances have been investigated by many experimenters; but the only absolute determinations yet made in this most important subject are due to Professor James Forbes *, who has deduced the absolute thermal conductivity of the trap rock of Calton Hill, of the sandstone of Craigleith Quarry, and of the sand below the soil of the Experimental Gardens, from observations on terrestrial temperature, which were carried on for five years in these three localities (all in the immediate neighbourhood of Edinburgh), by means of thermometers constructed and laid, under his care, by the British Association. The author of the present communication explained briefly a method of reduction depending on elementary formulæ of the theory of the conduction of heat given by the great French mathematician Fourier, which proved to be more complete and satisfactory than the method indicated by Poisson, which had been adopted by Professor Forbes. He applied it both to the series of observations used by Professor Forbes, and to a continuation of the observations on the trap rock of Calton Hill, which has been carried on up to the present time at the Royal Observatory of Edinburgh, and of which eleven years complete have been supplied to the author in manuscript, through the kindness of Professor Piazzi Smyth. The results, as regards thermal conductivities, show that the determinations originally given by Professor Forbes do not require very considerable corrections; and are satisfactory, inasmuch as values derived from the diminution of the extent of variation of the temperature for the deep thermometers agree very closely with those derived from the retardation of the periods of summer heat and winter cold at the different depths. They show very decidedly a somewhat greater conductivity of the trap rock at the greater depths (from twelve to twenty-four feet) than between the three feet deep and the six feet, or between the six feet and the twelve feet thermometers, but do not establish any such variation in the properties of the sandstone, and of the sand of the two other localities. A comparison of the mean temperatures of the four thermometers, for the whole sixteen years' observation, shows an increase of indicated temperature in going downwards in Calton Hill, which apparently is much more rapid between the upper than between the lower thermometers; so much so, as not to be referable to the greater conductivity of the rock in the lower position. The author remarked, that, to make the observations available for giving with accuracy the mean absolute temperatures at the different depths, it would be necessary to have the thermometers taken up and re-compared with a standard thermometer. It is most probable that the zero-points of all the thermometers have risen considerably since they were first laid, because the apparent mean temperatures, as shown by the thermometers, are much higher of late than they were at first. Thus, for the period of five years examined by Professor Forbes, and for the succeeding period of eleven years, the means at the different depths are as follows:—

* Account of some Experiments on the Temperature of the Earth near Edinburgh, Trans. Roy. Soc. Edinb. vol. xvi. part 2.

Trap Rock of Calton Hill.

	3 feet deep.	6 feet deep.	12 feet deep.	24 feet deep.
Period 1837 to 1842	45·49	45·86	46·36	46·87
" 1843 to 1854	46·512	46·751	47·035	47·349

Notwithstanding the cause of uncertainty which has been alluded to, these results make it highly probable that the augmentation of mean temperature from 3 feet to 24 feet below the surface, apparently 1°·38 Fahr. in the first period and ·84° in the second period, must be really more than half a degree, or more than the greatest elevation of temperature that had been observed, for a depth of 21 feet, in any other part of the earth. The author was struck with this, and reflecting that probably the Edinburgh observations are the only ones that have been made on the interior temperature of other igneous rocks than granite, supposed it to indicate the comparatively modern time at which the trap rock of Calton Hill has burst up in an incandescent fluid state. This conjecture, shortly after it occurred to him, was confirmed by the intelligence he received at Kreuznach, in Rhenish Prussia, that the temperature in the porphyry of that locality increases at the rate of from 2° to 3° Reaumur in 100 feet downwards, being more than double or triple the rate of augmentation which had been observed in numerous localities in England, France, and other parts of Europe, in granitic rocks and sedimentary strata, and found to be about 1° Fahr. of elevation of temperature in fifteen yards at the least or in twenty yards at the greatest, as Professor Phillips has shown in his Treatise on Geology, in Lardner's Cyclopædia, from careful observations made by himself and others. The author pointed out, that the mathematical theory of heat,—with data as to absolute conductivities of rocks, such as those supplied by Professor Forbes, and with the assistance of observation on the actual cooling of historic lava streams, such as the great outbreak from Etna which overthrew Catania in 1669, or of those of Vesuvius which may be seen in the incandescent state, and observed for temperature a few weeks or months after the commencement of solidification,—may be applied to give estimates, within determined limits of accuracy, of the absolute dates of eruption of actual volcanic rocks of prehistoric periods of geology, from observations of temperature in bores made into the volcanic rocks themselves and the surrounding strata.

On the Electric Qualities of Magnetized Iron. *By* Professor W. Thomson, *M.A., F.R.S.*

The well-known ordinary phænomena of magnetism prove that there is a wonderful difference between the mutual physical relations of the particles of a mass of iron according as it is magnetized or in an unmagnetic condition. Joule's important discovery, that a bar of iron, when longitudinally magnetized, experiences an increase of length, accompanied with such a diminution of its lateral dimensions as to leave its bulk unaltered, is the first of a series by which it may be expected we shall learn that all the physical properties of iron become altered when the metal is magnetized, and that in general those qualities which have relation to definite directions in the substance are differently altered at different inclinations to the direction of magnetization. In the present communication, the author described experiments he had made—with assistance in defraying the expenses from the Royal Society, out of the Government grant for scientific investigations—to determine the effects of magnetization on the thermo-electric qualities, and on the electric conductivity, of iron.

The first result obtained was, that longitudinally magnetized iron wire, in an electric circuit, differs thermo-electrically in the same direction as antimony from unmagnetized iron. This any one may verify with the greatest ease by applying a spirit-lamp to heat the middle of an iron wire or thin rod of iron a couple of feet long, with a little magnetizing coil of copper wire (excited by a cell or two of any ordinary galvanic battery) adapted to slide freely on it, and so bring a magnetizing force to act on two or three inches in any part of the length of the iron; and, when

the ends of the iron conductor are connected with the electrodes of an astatic needle galvanometer of very moderate sensibility, suddenly moving the coil from one side to the other of the flame of the spirit-lamp.

The author next explained a series of experiments (not so easily described without the apparatus which was exhibited to the Section, or drawings of it), by which it was ascertained that magnetized iron, with electric currents crossing the lines of magnetization at right angles, differs from unmagnetized iron, thermo-electrically, in the same direction as *bismuth*, that is, in the opposite way to that previously found for iron magnetized along the line of current; and it was verified that an iron conductor, obliquely magnetized, and placed in a circuit of conducting matter, has a current excited through it when its two polar sides are maintained at different temperatures. The author also described and exhibited an experimental arrangement made, but not yet sufficiently tried, to test whether or not magnetized iron possesses a certain thermo-electric rotatory property which his theory of thermo-electricity in crystalline conductors had led him to believe might possibly exist in every substance possessing, either intrinsically or inductively, such a dipolar directional property as that of magnetism.

Regarding the thermo-electric properties of magnetized steel, the only experiments yet made, being on longitudinal magnetization, showed most decidedly the same kind of effect subsisting with the permanent magnetization, after the magnetizing agency is withdrawn, as had been found in iron while actually sustained in a state of magnetization by the electro-magnetic force.

The effects of magnetism on the conductivity of iron both for heat and electricity, in different directions with reference to the direction of magnetization, had been tested by different experimenters with no confirmed indications in the conduction of heat, and with only negative results regarding electric conductivity. The author of the present communication, feeling convinced that only tests of sufficient power are required to demonstrate real effects of magnetization on all physical properties of iron, tried to ascertain the particular nature of the conjectured effect in the case of electric conductivity; and at last, after many unsuccessful attempts, succeeded in establishing, that an iron conductor, sustained in a magnetic condition by a longitudinal magnetizing force, and brittle steel wires retaining longitudinal magnetism, resist the passage of electricity more, or, which is the same, possess less electric conductivity, than the same conductors when unmagnetic. It remains to be seen whether either iron or steel has, when magnetized, the electro-crystalline property of possessing different electric conductivities in different directions; and whether either has the possible rotatory property as regards conduction, which the intrinsically dipolar type of magnetization suggests.

It is important to observe, that both the thermo-electric quality, and the effect on electrical conductivity induced in iron or steel, and sustained by the magnetizing force, are retained with the permanent magnetism in steel after the magnetizing force is removed, as Joule found to be the case with the alteration of dimensions, which he discovered as an effect of magnetism; while on the other hand, as the author showed in a previous communication to the Section, the thermo-electric quality he had discovered as an effect of mechanical strain, becomes reversed when the constraining force has been removed, if any permanent strain has been produced.

On the Thermo-Electric Position of Aluminium. *By* Professor W. Thomson, *M.A.*, *F.R.S.*

The author, through the kindness of Baron Liebig, having been enabled to make experiments on a bar of aluminium with a view to investigating its thermo-electric properties, found that it gave currents when its ends were at different temperatures, and an inch or two of its length was included in the circuit of a galvanometer by means of wires of copper, of lead, of tin, or of platinum, bent round it. These currents were in such directions as to show that the Aluminium lies, in the thermo-electric series, on the side towards bismuth, of Tin, Lead, Copper, and a certain platinum wire (P_2); and, on the side towards Antimony, of another platinum wire (P_3). They were in the same direction as regards the higher and lower temperatures of the two junctions of the aluminium with the other

metal in each case, whether the whole bar was heated so much by a spirit-lamp that it could scarcely be held in the hand, or no part of it was heated above the temperature of the air, and one end cooled by being covered with cotton kept moistened with æther. Taking into account the results of previous experiments which the author had made on a number of different metals, including three specimens of platinum wire (P_1, P_2, P_3), probably differing from one another as to chemical purity, which he used as thermo-electric standards, he concluded that at temperatures of from 10° to 32° Cent., the following order subsists unchanged as regards the thermo-electric properties of the metals mentioned:—Bismuth, P_3, Aluminium, Tin, Lead, P_2, Copper, P_1, Zinc, Silver, Cadmium, Iron. As he had found that a brass wire, on which he experimented, is neutral to P_3 at −10° Cent., and to P_2 at 38°, he infers that at some temperature between −10° and 38° Aluminium must be neutral either to the brass or to P_3. He intends, as soon as he can procure a few inches of aluminium wire to experiment with, to determine this neutral point, and others which he infers from the experiments already made, will probably be found at some temperature not very low, between Aluminium and Tin, and Aluminium and Lead; and to look for neutral points which may possibly be found between Aluminium and P_3 and Aluminium and P_2, at either high or low temperatures.

On Peristaltic Induction of Electric Currents in Submarine Telegraph Wires. By Professor W. Thomson, *M.A., F.R.S.*

Recent examinations of the propagation of electricity through wires in subaqueous and subterranean telegraphic cables, have led to the observation of phænomena of induced electric currents, which are essentially different from the phænomena (discovered by Faraday many years ago) of what has hitherto been called electro-dynamic, or electro-magnetic induction, but which, for the future, it will be convenient to designate exclusively by the term electro-magnetic. The new phænomena present a very perfect analogy with the mutual influences of a number of elastic tubes bound together laterally throughout their lengths, and surrounded and filled with a liquid which is forced through one or more of them, while the others are left with their ends open or closed. The hydrostatic pressure applied to force the liquid through any of the tubes will cause them to swell, and to press against the others, which will thus, by peristaltic action, compel the liquid contained in them to move in different parts of them in one direction or the other. A long solid cylinder of India-rubber, bored symmetrically in four, six, or more circular passages parallel to its length, will correspond to an ordinary telegraphic cable containing the same number of copper wires, separated from one another only by gutta percha; and the hydraulic motion will follow rigorously the same laws as the electrical conduction, and will be expressed by identical language in mathematics, provided the lateral dimensions of the bores are so small, in comparison with their lengths, or the viscosity of the fluid so great, that the motions are not sensibly affected by inertia, and are consequently dependent altogether on hydrostatic pressure and fluid friction. Hence the author considers himself justified in calling the kind of electric action now alluded to, *peristaltic induction*, to distinguish it from the electro-magnetic kind of electro-dynamic induction. The mathematical treatment of the problem of mutual peristaltic induction is contained in the paper brought before the Section; but the author confined himself in the meeting to mentioning some of the results. Among others, he mentioned, as being of practical importance, that the experiments which have been made on the transmission of currents backwards and forwards by the different wires of a multiple cable, do not indicate correctly the degree of retardation that is to be expected when signals are to be transmitted through the same amount of wire laid out in a cable of the full length. It follows, that expectations as to the working of a submarine telegraph between Britain and America, founded on such experiments, may prove fallacious; and to avoid the chance of prodigious losses in such an undertaking, the author suggested that the working of the Varna and Balaklava wire should be examined. He remarked that a part of the theory communicated by himself to the Royal Society last May, and published in the Proceedings, shows that a wire of six times the length of the Varna and Bala-

klava wire, if of the same lateral dimensions, would give thirty-six times the retardation, and thirty-six times the slowness of action. If the distinctness of utterance and rapidity of action practicable with the Varna and Balaklava wire are only such as to be not inconvenient, it would be necessary to have a wire of six times the diameter; or better, thirty-six wires of the same dimensions; or a larger number of still smaller wires twisted together, under a gutta percha covering, to give tolerably convenient action by a submarine cable of six times the length. The theory shows how, from careful observations on such a wire as that between Varna and Balaklava, an exact estimate of the lateral dimensions required for greater distances, or sufficient for smaller distances, may be made. Immense economy may be practised in attending to these indications of theory in all submarine cables constructed in future for short distances; and the non-failure of great undertakings can alone be *ensured* by using them in a preliminary estimate.

On new Instruments for Measuring Electrical Potentials and Capacities. By Professor W. Thomson, *M.A., F.R.S.*

In this communication three instruments were described and exhibited to the Section: the first a standard electrometer, designed to measure, by a process of weighing the mutual attraction of two conducting discs, the difference of electrical potential between two bodies with which they are connected, an instrument which will be useful for determining the electromotive force of a galvanic battery in electrostatic measure, and for graduating electroscopic instruments so as to convert their scale indications into absolute measure; the second an electroscopic electrometer, which may be used for indicating electrical potentials in absolute measure, in ordinary experiments, and, probably with great advantage, in observations of atmospheric electricity; and the third, for which a scientific friend has suggested the name of Electroplatymeter, an instrument which may be applied either to measure the capacities of conducting surfaces for holding charges of electricity, or to determine the electric inductive capacities of insulating media.

On the Means proposed by the Liverpool Compass Committee for carrying out Investigations relative to the Laws which govern the deviation of the Compass. By John T. Towson.

Experimental Demonstration of the Polarity of Diamagnetic Bodies. By Professor Tyndall, *F.R.S.*

The author referred to the Bakerian Lecture of the present year, as proving that a bar of bismuth freely suspended within a spiral of copper wire, excited by a current passing through that wire and acted upon by external magnets, could be attracted and repelled with the same certainty as, though with a far less energy than, a bar of iron, the sense of the deflection, which indicated the polarity of the diamagnetic bismuth bar, being always opposed to the deflection of the iron bar under the same circumstances. The experiments now described formed the complement, so to speak, of those described in the lecture referred to. In the latter case, the bismuth bar was deflected by magnets; but as the action is mutual, it is to be expected that the magnets, if properly arranged, could be deflected by the diamagnetic bars. An experiment of this nature has already been made by Prof. Weber of Göttingen, but the results obtained by this distinguished experimenter have not commanded general conviction; they have been questioned by Matteucci, Von Feilitzsch, and others. Prof. Tyndall has to thank M. Weber for the plan of an instrument, constructed by M. Leyser of Leipsic, which has enabled him to remove the last trace of doubt from this important question. The instrument consists essentially of two upright spirals of copper wire about 18 inches long, fastened to a stout slab of wood, enclosed on all sides during the time of experiment, and so fixed into solid masonry that the spirals are vertical. Above the spirals is a wooden wheel with a grooved circumference; below the spirals there is a similar wheel; an endless string passed tightly round both wheels, and to this string are attached two cylinders of the diamagnetic body to be examined.

By turning the lower wheel by a suitable key, the cylinders may be moved up and down within the spirals. Two steel bar magnets are arranged to an astatic system, connected together by a rigid brass junction, and suspended so that both magnets are in the same horizontal plane. It is so arranged that these two magnets have the two spirals between them, and have their poles opposite to the centre of the spirals. When, therefore, a current is sent through the spirals, it exerts no more action on the magnets than the centre or neutral point of a magnet would do. Supposing the bars within the spirals to be also perfectly central, they also present their neutral points to the magnetic poles, and hence exert no action upon it. But if the key be turned so as to bring the two *ends* of the diamagnetic bars to act upon the suspended magnets, if the bars be polar, the magnitude and nature of their polarity will be indicated by the consequent deflection of the magnets. The index by which the deflection of the magnets is observed is a ray of light reflected from a mirror attached to the magnets; and as the length of this ray may be varied at pleasure, the sensibility of the instrument may be indefinitely increased. When cylinders of bismuth are submitted to experiment, a very marked deflection is produced, indicating a polarity on the part of the bismuth opposed to the polarity of iron. This is the result already obtained by M. Weber; but against it, it has been urged that the deflection is due to induced currents excited in the metallic cylinders during their motion within the spirals. To this objection Prof. Tyndall replied as follows:—first, the deflection produced was a *permanent* deflection, which could not be the case if it were due to the momentary currents of induction; secondly, if due to induction, copper ought to show the effect far more energetically than bismuth, for its conducting power and, consequently, the facility with which such currents are produced, is fifty times greater than that of bismuth; but with cylinders of copper no sensible deflection was produced; thirdly, two prisms of the heavy glass with which Mr. Faraday discovered the diamagnetic force and produced the rotation of the plane of polarization of a luminous ray, were substituted for the metallic cylinders; and although the action was far less energetic, it was equally certain as in the case of bismuth, and indicated the same polarity. The formation of induced currents is wholly out of the question here, for the substance is an insulator. The experiments, therefore, remove the last remaining doubt from the proposition, that diamagnetic bodies under magnetic excitement possess a polarity which is the reverse of that possessed by magnetic ones.

Experimental Observations on an Electric Cable. *By* Wildman Whitehouse.

After referring to the rapid progress in submarine telegraphy which the last four years have witnessed, Mr. Whitehouse said that he regarded it as an established fact, that the nautical and engineering difficulties which at first existed had been already overcome, and that the experience gained in submerging the shorter lengths had enabled the projectors to provide for all contingencies affecting the greater. The author then drew the attention of the Section to a series of experimental observations which he had recently made upon the Mediterranean and Newfoundland cables, before they sailed for their respective destinations. These cables contained an aggregate of 1125 miles of insulated electric wire, and the experiments were conducted chiefly with reference to the problem of the practicability of establishing electric communications with India, Australia, and America. The results of all the experiments were recorded by a steel style upon electro-chemical paper by the action of the current itself, while the paper was at the same time divided into seconds and fractional parts of a second by the use of a pendulum. This mode of operating admits of great delicacy in the determination of the results, as the seconds can afterwards be divided into hundredths by the use of a "vernier," and the result read off with the same facility as a barometric observation. Enlarged fac-similes of the electric autographs, as the author calls them, were exhibited as diagrams, and the actual slips of electro-chemical paper were laid upon the table. The well-known effects of induction upon the current were accurately displayed; and contrasted with these were other autographs showing the effect of forcibly discharging the wire by giving it an adequate charge of the opposite electricity in the

mode proposed by the author. No less than eight currents—four positive and four negative—were in this way transmitted in a single second of time through the same length of wire (1125 miles), through which a single current required a second and a half to discharge itself *spontaneously* upon the paper. Having stated the precautions adopted to guard against error in the observations, the details of the experiments were then concisely given, including those for "velocity," which showed a much higher rate attainable by the magneto-electric than by the voltaic current. The author then recapitulated the facts, to which he specially invited attention:—First, the mode of testing velocity by the use of a voltaic current divided into two parts (a split current), one of which shall pass through a graduated resistance tube of distilled water, and a few feet only of wire, while the other part shall be sent through the long circuit, both being made to record themselves by adjacent styles upon the same slip of electro-chemical paper. Second, the use of magneto-electric "twin-currents," synchronous in their origin, but wholly distinct in their metallic circuits, for the same purpose, whether they be made to record themselves direct upon the paper, or to actuate relays or receiving instruments which shall give contacts for a local printing battery. Third, the effects of induction, retardation of the current, and charging of the wire, as shown autographically; and contrasted with this—fourth, the rapid and forcible discharging of the wire by the use of an opposite current; and hence—fifth, the use of this as a means of maintaining, or restoring at pleasure, the electric equilibrium of the wire. Sixth, absolute neutralization of currents by too rapid reversal. Seventh, comparison of working speed attainable in a given length of wire by the use of repetitions of similar voltaic currents as contrasted with alternating magneto-electric currents, and which, at the lowest estimate, seemed to be seven or eight to one in favour of the latter. Eighth, proof of the co-existence of several waves of electric force of opposite character in a wire of given length, of which each respectively will arrive at its destination without interference. Ninth, the velocity, or rather amount of retardation, greatly influenced by the energy of the current employed, other conditions remaining the same. Tenth, no adequate advantages obtained in a 300-mile length by doubling or trebling the mass of conducting metals. The author, in conclusion, stated his conviction, that it appeared from these experiments, as well as from trials which he had made with an instrument of the simplest form, actuated by magneto-electric currents, that the working speed attainable in a submarine wire of 1125 miles was ample for commercial success. And may we not, he added, fairly conclude also, that India, Australia, and America, are accessible by telegraph without the use of wires larger than those commonly employed in submarine cables?

On the New Maximum Thermometer of H. Negretti *and* Zambra. *Communicated by* C. Greville Williams.

The very simple but effective instrument for indicating maximum temperature, invented by Messrs. H. Negretti and Zambra, is remarkable both for the delicacy of the workmanship and for the difficulty which is found in constructing it, a difficulty which is entirely of a practical character, and prevents the possibility of a perfect instrument being constructed by any but a dextrous artist.

It consists of a thermometer-tube bent near the bulb, in the manner of the old ones, but just at the bend the tube has an impediment caused by a contraction at that point. This choking of the tube is insufficient to prevent the easy passage of the mercury during its expansion, but nevertheless effectually prevents its return as the temperature falls, and the mercury in the globe consequently occupies less space. The portion left in the stem serves as the index of the highest temperature arrived at.

It is acknowledged that a certain amount of error is here unavoidably introduced, from the fact that the mercury at the time of passage into the tube is at a higher temperature than when the observation is made, and occupies a larger space in the tube. Consequently, the instrument when read off indicates a lower temperature than the truth; but although this objection may justly be made on theoretical grounds, in practice the effect of this error on the result is inappreciable, owing to the very small quantity of the mercury in the tube.

When it is required to return the mercury to the bulb for the purpose of making a fresh observation, the end furthest from the bend is to be elevated, and the instrument slightly agitated; by this means the metal repasses the obstruction and indicates the temperature at the time.

Mr. Williams called the attention of the Section to the advantages of having the scale engraved on the stem of the instrument, thus preventing the danger of error from alteration of the scale, which may result from wooden ones being exposed to damp, or too high a temperature. The instrument is also provided with another glass scale more boldly graduated, attached to the tube, to facilitate reading off.

Astronomy, Meteors, Waves.

On the Establishment of a Magnetic Meteorological and Astronomical Observatory on the Mountain of Angusta Mullay, at 6200 *feet, in Travancore. By* Astronomer Broun. (*Communicated by* Colonel Sykes.)

Astronomer Broun, in a letter to Colonel Sykes dated 2nd of July, 1855, describes the successful establishment of an observatory on Angusta Mullay, at 6200 feet above the sea-level, for the purpose of simultaneous record with the Observatory at Trevandrum.

The difficulties of access to the summit of the mountain were so great, from having to cut paths through dense jungles infested by elephants and other wild animals, from having to use ropes and mechanical aid in getting up the building materials, provisions, and the instruments, and in the delays from the labourers running away from fright and the effects of cold, that two years were consumed in the undertaking. The object of Astronomer Broun, in making known his successful efforts in Europe, is to enable observers to put themselves into communication with him, in case they should desire to have any experimental researches made in so novel a position for an observatory.

On certain Anomalies presented by the Binary Star 70 *Ophiuchi. By* W. S. Jacob, *Director of the Madras Observatory.*

This pair has been long known as a binary system, but the exact orbit is yet in doubt, although nearly a whole revolution has been completed since it was first observed in 1779.

All the orbits that have been computed fail in representing the true positions at certain points, and those which best represent the angles fail entirely as regards the distances.

The most remarkable point is, that even in those orbits which agree best with observation, the errors in the angles assume a periodical form, retaining the same sign through a considerable space.

An orbit has been computed with a period of ninety-three years, in which the errors are + from 1820 to 1823, — with one exception from 1823 to 1830, doubtful from 1830 to 1832, and from 1833 to 1842 all +, after which they continue for the most part —.

This must depend upon some law: it *might* arise from a change in the law of gravitation, but may be accounted for more simply by supposing the existence of a third opake body perturbing the other two. Such bodies have been already surmised to account for irregular motion of apparently single stars, such as Sirius and Procyon.

The body in this case, if supposed to circulate as a planet round the smaller star, need not be very large, as the deviation from the ellipse does not exceed $0''\cdot 1$ of arc.

Assuming the small star to describe a secondary ellipse, in which $a=0''\cdot 08$, $e=0\cdot 15$, $P=26$ years, and $\varpi=200°$, and applying corresponding corrections to the positions, the average error in the angles is reduced from $50'$ to $37'$, and in the distances measured subsequent to 1837 from $0''\cdot 14$ to $0''\cdot 11$, or by about $\frac{1}{5}$.

There is therefore *primâ facie* evidence for the existence of such a body, and it is desirable that the fact should be still further tested by careful observation.

On the Calculation of an Observed Eclipse or Occultation of a Star. *By* Professor Mossotti.

According to the denominations adopted in Dr. Pearson's 'Introduction to Practical Astronomy,' vol. ii. p. 675, and following, the general equation for an eclipse, a passage of a planet over the sun, or an occultation of a star is—

$$(m - \pi\,\mu)^2 + (n - \pi\,\nu)^2 = (d + \mathrm{D} - f - \pi\,\omega \tan(\mathrm{D} - f))^2.$$

This equation, by introducing a new angle ξ, may be resolved into the following two:—

$$(m - \pi\,\mu)\cos\xi + (n - \pi\,\nu)\sin\xi = d + \mathrm{D} - f - \pi\,\omega\tan(\mathrm{D} - f) \quad . \quad . \quad (a)$$

$$-(m - \pi\,\mu)\sin\xi + (n - \pi\,\nu)\cos\xi = 0, \quad . \quad . \quad . \quad . \quad . \quad . \quad (b)$$

the last of which gives

$$\tan\xi = \frac{n - \pi\,\nu}{m - \pi\,\mu} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (c)$$

The angle ξ given by this formula may be computed by the values of m, n, and π, deduced from the lunar tables, and the small error by which they may still be affected will not have any sensible influence upon equation (a), because the fluxion for a change in the value of the angle ξ is evidently reduced to nothing in consequence of the second equation (b). On this property lies the foundation of the method which we are going to explain.

If we count the time t from the instant of the observation, the values of the cosines m_0 and n_0 corresponding to the instant of the true conjunction may be expressed by series*—

$$m_0 = m + m'\,t + \frac{1}{2}\,m''\,t^2 + \omega,$$

$$n_0 = n + n'\,t + \frac{1}{2}\,n''\,t^2 + \omega:$$

but at the moment of the true conjunction, we must have

$$m_0 = 0, \quad n_0 = b_0 - \mathrm{B}_0,$$

therefore

$$m = -\,m'\,t - \frac{1}{2}\,m''\,t^2,$$

$$n = b_0 - \mathrm{B}_0 - n'\,t - \frac{1}{2}n''\,t^2;$$

and by substituting these expressions in equation (a), and by putting, for sake of an easier computation,

$$m' = v\cos\mathrm{O}, \qquad \mu = \sin\zeta\cos\nu, \qquad m'' = w\cos\epsilon,$$

$$n' = v\sin\mathrm{O}, \qquad \nu = \sin\zeta\sin\nu, \qquad n'' = w\sin\epsilon,$$

we shall have

$$-\,t\,v\cos(\xi - \mathrm{O}) + (b_0 - \mathrm{B}_0)\sin\xi - \pi\sin\zeta\cos(\xi - \nu) - (d + \mathrm{D} - f) =$$

$$-\,\pi\cos\zeta\tan(\mathrm{D} - f) + \frac{1}{2}\,t^2\cos(\xi - \epsilon).$$

The letter t denotes the time elapsed from the instant of the observation to that of conjunction, and its value is negative when the conjunction happens before; then, if we call T the mean time of observation, as counted at the place, and Λ the eastward longitude of the place from the meridian for which the time Θ of conjunction has been computed, which will commonly be the meridian of the lunar tables employed, we must have

$$\mathrm{T} + t = \Theta + \Lambda,$$

and the preceding equation may assume the form

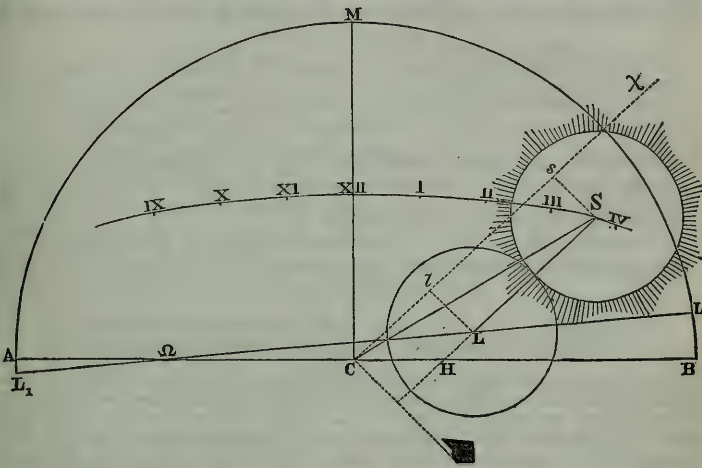
$$\left.\begin{array}{l}\Theta\,v\cos(\xi-\mathrm{O})+\Lambda\,v\cos(\xi-\mathrm{O})-(b_0-\mathrm{B}_0)\sin\xi+\pi\sin\zeta\cos(\xi-\nu)+d+\mathrm{D}=\\ \mathrm{T}\,v\cos(\xi-\mathrm{O})+f-\pi\cos\zeta\tan(\mathrm{D}-f)-\frac{1}{2}\,t^2\,w\cos(\xi-\epsilon).\end{array}\right\}\ (\mathrm{A})$$

The values of the coefficients $v\cos(\xi-\mathrm{O})$, $\sin\xi$, $\sin\zeta\cos(\xi-\nu)$, as well as those of the last two terms of the second member, may be computed by the elements

* See the Note II. at the end.

drawn from lunar tables without any sensible error arising in our equation; T and f are given by observation, only the quantities Θ, Λ, $b_0 - B_0$, π and $d + D$, or some of them may form the queries of the problem, according to circumstances; and as all these quantities are contained under a linear form, their determination can be directly obtained by the resolution of equations of first degree, without having recourse to the method of corrections by supposed errors, which is an analytical and practical advantage of the formula we propose.

If we refer to a construction upon the usual plane of projection, as seen in the annexed figure, it will be easily seen that the angle ξ which we have employed is



the angle, S H A, which the line, S L, uniting the apparent centres, S and L, of the occulting and occulted bodies, makes with A B, the perpendicular to the projection, C M, of the circle of declination; O is the angle, L′ ☊ B, which the relative orbit, L_1 L L′, of the occulting body makes with the same perpendicular, v the relative velocity of this body in its orbit, ζ the zenith distance, C S, of the occulted body, and ν the complement, S C A, of its angle of variation. This being understood, it is clear that the leading idea of our method consists in valuing the abscissæ C l, C s of the projected centres of the said bodies, at the instant of the observation, and in a direction parallel to the line which unites them, and to make the sum of their projected semidiameters, diminished by the phasis, equal to the difference of those abscissæ, upon the length of which difference a small error on the angle ξ has no important influence.

Note I.—In the expressions of m and n, given at page 635 of the quoted work, it is supposed that A, a, B and b denote the right ascensions and declinations of the occulting and occulted bodies, but we may suppose as well that they represent their longitudes and latitudes. In this case, calling P the angle of position of the occulted body* at the instant of the observation, we must compute ξ by formula

$$\tan \xi = \frac{m \sin P + n \cos P - \pi \nu}{m \cos P - n \sin P - \pi \mu}; \quad \ldots\ldots \quad (c)'$$

and we must substitute in formula (A) $\xi - P$ and $\nu - P$ instead of ξ and ν. Then Θ will be the time of conjunction in longitude, and $b_0 - B_0$ the difference of latitude of the two bodies; but in the expressions of μ, ν and ω, the letters a and b will continue to represent the right ascension and declination of the occulted body, and

* The angle of position P is to be taken positive in the ascending signs of the ecliptic ♈♋, and negative in the descending signs ♋♎♓.

their values, as well as that of P, are only wanted to be known to the nearest minute. The angle ξ given by formula (c) or (c)′, ought to be taken lesser or greater than 180°, according as the values of the numerators will be positive or negative.

Note II.—The fluxions or derivates m', n'; m'', n'' of first and second order, may be valued by employing the corresponding horary motions given by tables, which would be more analytical, but in practice it will be found more convenient to take out from the 'Nautical Almanac,' or from other sources, for an hour before, the instant of the observation, for this instant, and for an hour after, the necessary elements for computing three successive values, m_{-1}, m, m, and n_{-1}, n, n_1, and to make

$$' = m\,\frac{m_1 - m + (m - m_{-1})}{2}, \qquad n' = \frac{n_1 - n + (n - n_{-1})}{2}$$

$$\frac{1}{2}\,m'' = \frac{m_1 - m - (m - m_{-1})}{2}, \qquad \frac{1}{2}\,n'' = \frac{n_1 - n - (n_1 - n_{-1})}{2}$$

I subjoin here some faults of printing discovered in Dr. Pearson's work:—

At page 634, line 13, read *place* instead of *plane*.

At page 635, line 10, the formulæ must be

$$m = \cos B \cos (a - A), \qquad n = \sin b \cos B \cos (a - A) - \cos b \sin B.$$

At page 635, line 10, read 34′ 57″ instead of 3′ 51″.

Remarks on the Chronology of the Formations of the Moon. By Professor Nichol, *LL.D., Observatory, Glasgow.*

Prof. Nichol stated, that, through the munificence of the Marquis of Breadalbane, he had been enabled to bring to bear on the delicate inquiries, whose commencement he intended to explain, a very great, if not a fully adequate amount of telescopic power. A speculum of twenty-one inches, originally made by the late Mr. Ramage with the impracticable focal length of *fifty-five feet,* had, at the expense of that noble Lord, been re-ground, polished, mounted as an equatoreal, and placed in the Glasgow Observatory, in its best state, only about six weeks ago. Prof. Nichol showed some lunar photographs, which indicated the great light with which the telescope endowed its focal images, and entered on other details as to its *definition.* The object of the present paper is the reverse of speculative. It aims to recall from mere speculation, to the road towards positive inquiry, all observers of the lunar surface. To our satellite hitherto those very ideas have been applied, which confused the whole early epochs of our terrestrial geology, the notion, viz. that its surface is a *chaos,* the result of primary, sudden, short-lived and lawless convulsion. We do not now connect the conception of irregularity with the history of the earth:—it is the triumph of science to have analysed that apparent chaos, and discerned order through it all. The mode by which this has been accomplished, it is well known, has been the arrangement of our terrene mountains according to their relation to time: their relative ages determined, the course of our world seemed smooth and harmonious, like the advance of any other great organization. Ought we not then to attempt to apply a similar mode of classification to the formations in the moon,—hoping to discern there also a course of development, and no confusion of manifestation of irregular convulsion? Prof. Nichol then attempted to point out that there appeared a practical and positive mode by which such classification might be effected. It could not, in so far as he yet had discerned, be accomplished by tracing, as we had done on earth, relations between lunar upheavals and stratified rocks; but another principle was quite as decisive in the information it gave, viz. the intersection of dislocations. There are clear marks of dislocation in the moon; nay, the surface of our satellite is overspread with them. These are the rays of light, or rather bright rays, that flow from almost all the great craters as their centres, and are also found where craters do not at present appear. Whatever the substance of this highly reflecting matter, it is evidently no superficial layer or stream, like lava, but extends

downwards a considerable depth into the body of the moon. In short, we have no likeness to it on earth, in the sense now spoken of, except our great trap and crystalline *dykes*. It seemed clear, then, that the intersection of these rays are really *intersections of dislocations*, from which we might deduce their chronology. Can the intersection, however, be sufficiently seen? in other words, Is the telescope adequate to determine which of the two intersecting lines has disturbed or cut through the other? Prof. Nichol maintained the affirmative in many cases, and by aid of diagrams, taken down from direct observation, illustrated and enforced his views.

Note on Solar Refraction. *By* Professor C. Piazzi Smyth, *Royal Observatory, Edinburgh.*

Amongst other interesting and important consequences of the dynamical theory of heat, Prof. W. Thomson having deduced the necessity of a resisting medium, the condensation of this about the sun, and a consequent refraction of the stars seen in that neighbourhood, Prof. Piazzi Smyth had endeavoured to ascertain by direct astronomical observation, whether any such effect were sensible to our best astronomical instruments. Owing to atmospheric disturbances, only three observations, yielding two results, had been yet obtained; but both these indicated a sensible amount of solar refraction. Should this effect be confirmed by more numerous observations, it must have important bearings on every branch of astronomy; and as the atmosphere at all ordinary observatories presents almost insuperable obstacles, the author pointed out the advantage of stationing a telescope for this purpose on the summit of a high mountain.

On Altitude Observations at Sea. *By* Professor C. Piazzi Smyth, *Edinburgh.*

This paper treated mainly of the observation of altitudes at sea under circumstances when at present they are generally unattainable, viz. when the sea horizon is not visible. After a statement of the necessary principles which should guide inventors in this matter, the author exhibited a new species of artificial horizon, which allowed all the latitude of the natural horizon as to errors in the position of the whole sextant; and while exhibiting extreme sensibility to angular movement, was very little affected by any horizontal disturbance or translation through space.

Any still outstanding difficulties were effectually removed by the employment, in addition, of a stand, which taking advantage of the composition of rotatory motion and the permanence of an axis of rotation, as seen on the grand scale in the constancy of the annual direction of the earth's pole, or in the phænomenon of the precession of the equinoxes, and in a small way in a spinning-top, completely eliminated all the angular movements of which a ship is capable.

This second subject of the paper concludes thus:—"To the first idea of taking advantage of the general principle for the present purpose, I believe that I was led in a great degree by the eminently clear and practical manner in which the Rev. Baden Powell exhibited by models, and expounded in his lectures in 1852 and 1853, the action of the composition of rotatory motion under various circumstances in nature and in art; for then I perceived why 'Troughton's top' had so narrowly, but completely escaped the honour of becoming a useful instrument to nautical astronomy; and how what was good in it might be transferred to a better planned apparatus. More recently, as every one knows, M. Foucault has added a degree of glory even to the mechanical law, by employing another feature of it in his 'gyroscope,' as a means of detecting and exhibiting the rotation of the earth."

On the Transmission of Time Signals. *By* Professor C. Piazzi Smyth.

After alluding to the general subject of the longitude, the very large number of ships lost during the past year through errors of their longitude, and the recognized aids that have been furnished to seamen in the erection of time-balls, the author

described the recently erected time-ball on the Nelson Monument, on the Calton Hill, Edinburgh; which ball is dropped daily by a clock adjusted to true time in the Edinburgh Observatory, and acting through electric agency, in much the same way as at the Greenwich Observatory.

This electric agency having been proved, through a year and a half, to be most certain and accurate, and the ball proving of great advantage to Edinburgh and Leith, the question of extending the signal to the other parts of Scotland had been raised.

If only local means be provided for raising the balls, there can be no difficulty in dropping them with equal accuracy, and by the same electric contact which drops the Edinburgh time-ball, if they also be connected together metallically by the wires of the Electric Telegraph.

But, practically, there is some difficulty, or rather doubt, when the distance becomes great, on account of the loss of electricity by the way. An actual experiment, therefore, in the proposed locality, was important; and Sir T. Makdougall Brisbane, having long desired to see a time-ball established in Glasgow, most liberally volunteered to bear the expense of laying down temporary wires between the telegraph station and the meeting-room of Section G. The Royal Scottish Society of Arts lent a large model of a time-ball; and the Electric Telegraph Company lent many batteries, and the services of their practised assistants. With this help, the model was erected in the room of Section G, placed in electric connexion with the Edinburgh Observatory, and having been half raised at five minutes and full raised at two minutes before one o'clock, according to preliminary signals received, at one o'clock P.M. exactly, the ball was dropped by the Edinburgh clock at the same instant as it also dropped the Edinburgh time-ball.

METEOROLOGY.

On the Fall of Rain at Arbroath. *By* ALEXANDER BROWN, *Arbroath.*

The following Table, containing a synopsis of the depth of rain which falls at Arbroath, was compiled for insertion in the article "Forfarshire" in the forthcoming edition of the 'Encyclopædia Britannica,' and is one of a series for the purpose of showing the climate of that county:—

Years.	Spring.	Summer.	Autumn.	Winter.	Total.
	March. April. May.	June. July. August.	September. October. November.	December. January. February.	
	inches.	inches.	inches.	inches.	inches.
1845...	1·620	9·021	8·926	4·840	24·407
1846...	6·152	8·103	10·787	3·494	28·536
1847...	7·016	5·167	5·506	12·808	30·497
1848...	6·105	9·823	7·242	6·793	29·963
1849...	4·514	6·857	4·530	8·033	23·934
1850...	4·490	5·764	6·239	6·212	22·705
1851...	7·280	7·308	3·481	6·869	24·938
1852...	2·323	6·120	9·186	11·525	29·154
1853...	3·043	7·515	9·128	5·242	24·928
1854...	3·897	5·744	6·417	4·220	20·278
Mean...	4·644	7·142	7·144	7·004	25·934

From the Table, it appears that at Arbroath, in latitude 56° 34′ N., Longitude, 2° 35′ W., the mean annual fall of rain from ten years' observation, ending February

1855, was 25·934 (nearly 26) inches. Beginning the year with March, about one-sixth of the annual fall, or 4·644 inches, occurs in the three spring months of March, April, and May, and the remaining five-sixths, or 21·29 inches, in the summer, autumn, and winter months, the fall in each of the three latter quarters being nearly equal. In any three months during the period above-mentioned, the greatest fall was in the winter of 1847, 12·808 inches, and the least in the spring of 1845, 1·62 inch. The average number of days in each year on which rain fell was 146. The height of the rain-gauge above the sea is 40 feet, and 3 feet from the ground; distant from the sea three-eighths of a mile.

Remarkable Hailstorms in India, from March 1851 *to May* 1855. *By* Dr. George Buist, *F.R.S.* (*Communicated by* Colonel Sykes, *F.R.S.*)

Perhaps nowhere do the phænomena of hailstorms manifest themselves in such frequency and magnificence as in India, or present such opportunities of studying the matter itself with such care and advantage.

Reflecting on the imperfections of the records of these remarkable phænomena, the author resolved, in 1839, to prepare for publication a list of the more remarkable hailstorms that had occurred in India as far back as information permitted. The most invaluable assistance was derived in this inquiry, between the years 1816 and 1842, from the Asiatic Journal, a publication discontinued thirteen years ago, the second part (about the half) of each volume of which was filled with most judicious selections of extracts from the newspapers; the whole work being so admirably indexed, that anything contained in it, whether original or selected, might be examined with the utmost certainty, and almost without trouble. For the next ten years intervening betwixt 1841 and 1851, the newspapers required to be searched; a somewhat tiresome task, and one of considerable labour; so that it is not improbable that oversights may have occurred: since 1851, the extracts have been collected as they appeared in print.

The following will afford an outline of the conclusions I have for the present arrived at: I say for the present, for but few of them are fully established, and all stand in need of extension and elucidation :—

*Times when Hailstorms occur**.—Hailstorms occur in India, so far as appears from the published extracts, in the following proportions for the various months of the year :—

January	5	July	2
February	20	August	0
March	31	September	2
April	34	October	3
May	17	November	4
June	4	December	5

It will be seen that hail chiefly falls in our driest months, February, March, and April, and does not seem dependent on temperature; May, which supplies seventeen hailstorms, being the hottest month of the year, the true maxima due to the season being masked by the rains wherever these occur near the summer solstice. December and January, almost the coldest months, are nearly devoid of hail. We have a few instances of hail occurring in June and July in Central India, when the rains were late in setting in, but the hailstones in those cases were always small, and the falls light in comparison to those experienced in other periods of the year.

Hours when Hailstorms occur.—It very seldom happens that writers advert to the hours when hailstorms occur. Of a list of 30 published from the notes of that indefatigable observer Dr. Spilsbury, there are 10 set down as occurring at 3 or 4 P.M.; 1 at 4 P.M.; 4 at sunset; 5 at 11 A.M. or noon; 2 at 2 P.M.; 1 at 8 A.M.; and 1 at 9 A.M. Only 3 occur after dark, and none later than midnight.

* The author refers to and corrects some of the statements of Mrs. Somerville and Dr. Thomson.

Places from which Accounts of Hailstorms have been received, arranged chronologically.[*]

Meerut....1761, 1851, 1855	Saugor 1838, 1840, 1847	Gwalior 1850
Cawnpore 1817, 1855	Jessore..........1840	Rajpeepla 1850, 1851
Mirzapore 1819, 1852	Mandavee..........1840	Rajkote 1850
Jubbulpore, 1821–23–24–25–	Sukkur..........1844	Rungpore 1851
27–31–36–37–39–40–41	Sattara 1845, 1850, 1852	Ootacamund 1852
Bangalore 1822, 1851	Lahore 1847, 1853	Pondicherry..........1852
Monghyr 1823	Simla 1847, 1849, 1853	Tirhoot 1852
Kamptee 1823, 1831	Belgaum 1847, 1849	Shahpoor (Punjaub) ..1852
Lahargong 1825	Bancoora..........1847	Kalabagh..........1852
Bopalpore 1825	Near Nassick 1848	Landoor 1852
Garth 1825	Edulabad..........1848	Sealkote 1852
Serampore 1827, 1829	Broach..........1849	Kurrachee..1852, 1853, 1854
Tindolle 1827	Deesa 1849	Mahableshwar........1852
Kotah 1827	Indore 1849	Hydrabad (Sinde) 1852
Calcutta 1829	Jaulnah 1849	Ceylon 1852, 1855
Sylhet 1830	Rhotas..........1849	Ferozepoor 1853
Allahabad 1833	Tipperah 1849	Nainee Tal 1854
N. W. Mountains 1827, 1829	Purneah........1849, 1852	Roorkee 1854
Nagpoor 1831	Punjab..........1849	Neemuch 1854
Raneegunge..........1834	Bhooloola..........1849	Jouneer 1854
Poona 1834, 1847, 1853	Kurnool 1849	Poorundhur..........1854
Benares 1836	Peshawur 1849, 1853	Aurungabad 1854
Secunderabad ..1837, 1851	Dacca 1849	Bolarum 1855
Seetapore..........1838	Delhi 1849, 1851, 1853	Hurryhur..........1855
Near Calcutta 1838	Banda 1849	

Places where Hailstorms have occurred in India, arranged alphabetically.

Allahabad 1833	Jaulnah 1849	Pondicherry..........1852
Aurungabad 1854	Jessore..........1840	Poona 1834, 1847, 1853
Bancoora..........1847	Jooneer 1854	Poorundhur..........1854
Banda 1849	Jubbulpore 1821–23–24–25–	Punjaub 1849
Bangalore 1822, 1851	27–31–36–37–39–40–41	Purneah........1849, 1852
Belgaum........1847, 1849	Kalabagh..........1852	Rajkote 1850
Benares 1836	Kamptee 1823, 1831	Rajpeepla 1850, 1851
Bhooloola..........1849	Kotah 1827	Raneegunge..........1834
Bolarum 1855	Kurnool 1849	Rhotas..........1849
Bopalpore 1825	Kurrachee..1852, 1853, 1854	Roorkee 1854
Broach..........1849	Lahargong 1825	Rungpore..........1851
Calcutta 1829	Lahore 1847, 1853	Sattara....1845, 1850, 1852
Near Calcutta 1838	Landour 1852	Saugor....1838, 1840, 1847
Cawnpore 1817, 1855	Mahableshwur........1852	Sealkote 1852
Ceylon 1852, 1855	Mandvee 1840	Secunderabad ..1837, 1851
Dacca 1849	Meerut 1761, 1850, 1855	Seetapore..........1838
Deesa 1849	Mirzapore 1819, 1852	Serampore 1827, 1829
Delhi 1849, 1851, 1853	Monghyr 1823	Shahpore (Punjab) 1852
Edulabad..........1848	Nagpoor 1831	Simla 1847, 1849, 1853
Ferozepoor 1853	Nainee Tal 1854	Sukkur..........1844
Garth 1825	Near Nassick 1848	Sylhet 1830
Gwalior 1850	Neemuch 1854	Tindolle 1827
Hurryhur..........1855	N. W. Mountains 1827, 1829	Tipperah 1849
Hydrabad (Sinde) 1852	Ootacamund 1852	Tirhoot..........1852
Indore 1849	Peshawur 1849, 1853	

From the foregoing tables of localities where the hailstorms enumerated in my two lists have occurred, one very singular anomaly will become apparent—that whereas the Delta of the Ganges down to the sea, in lat. 22°, and but little raised above the highest tide, whose damp, tepid atmosphere contrasts as strikingly as possible with the pure crisp, vapourless air of the mountains, is the favourite locality of hailstorms, and whereas these are frequent along the western shore of the Bay of Bengal—from Surat south to Ceylon, in corresponding latitudes and altitudes on the Malabar coast, hail is a thing nearly unknown, though appearing in abundance immediately

to the north-westward, along the shores of Cutch and Sind, and to the eastward, as at Sattara, Mahableshwur, in the Ghauts, and all over the Deccan, so soon as we get some 1500 feet above the level of the sea. The climate of the eastern side of India is in summer somewhat drier and hotter, as it is colder in winter, than along the Malabar coast; but there is no such difference betwixt them as to explain, so far as appears, the absence of hail*.

In Europe and America, according to Dr. Thompson and Mrs. Somerville, hail rarely falls amongst or very near the mountains; in India no such law obtains. In my present and previous lists will be found accounts of hailstorms in the central provinces of Ceylon, at Ootacamund on the Neilgherries, both 6000 feet above the sea, and in contiguity with mountain masses of much greater elevation, Dodabetta in the latter case towering to the altitude of 8500 feet; at Sattara and Mahableshwur, in the Western Ghauts, 1700 and 4500 feet respectively; at Simla, 8000; at Nainee Tal, 6000; and at the Jummoo Highlands 1500 above the sea—the last three in the bosom of the Himalayas.

In Europe, hailstorms usually travel rapidly over the country in straight narrow bands, of vast length, but very small lateral extension. On the 24th of July, 1818, a hailstorm passed over the Orkneys from S.W. to N.E., twenty miles in length and a mile and a half in breadth: it travelled at the rate of a mile in a minute and a half, or the speed of a race-horse; ice covered the ground to the depth of 9 inches, though the storm at no given place endured beyond as many minutes†. In 1788, a hailstorm moved directly from the S.W. of France to the shores of Holland. It marched along in two columns, the breadth of that on the west being ten miles, that of the east five miles, with twelve miles between them. The one extended nearly 500 miles, the other 440 miles; the destruction occasioned by it amounted to close on a million sterling‡.

The Indian hailstorm falls in very limited patches, and seldom lasts above fifteen or twenty minutes; but the frequency with which hailstorms occur simultaneously at places remote from each other, but nearly in straight lines, seems to indicate a tendency on the part of the column to become continuous; probably they are at times more so than we imagine, only that such things are not made known to us where there are no Europeans, and where the country is thinly inhabited. The most noble of these are the hailstorms which fell on the 12th and 13th of May, 1853, at Ferozepore, Lahore, and Meean Meer, Peshawur, and Jummoo, places occupying a line of 350 miles in length, right across the Punjaub: unluckily the hours at which they occurred at these places respectively are not given.

Although this is the only instance I am aware of, of a series of hailstorms bursting out simultaneously, and, if not quite forming a continuous line, appearing somewhat like a string of beads stretched across the country, we have numbers of them occurring in pairs or in threes on the same day at places remote from each other. Our first outbursts of hail nearly always happen within a week or two of each other, at what may almost be termed the *glacial periods* of our climate; and I have no doubt that in many of these cases it would appear that there had been independent chains of hail showers, or of local atmospheric changes, many of which were accompanied by hail, had a greater abundance of records for reference existed. The following examples of this will be found in the printed list:—

Lohargong	60 miles apart, 9th February, 1825.	
Bhopalpore		
Jaulna	75 miles apart	14th May, 1849.
Aurungabad		
Deesa	350 miles from latter	

* In my previous paper, prepared by Colonel Sykes for the British Association, and given in abstract in their Reports for 1851, with some valuable emendations and additions of his own, it was stated that no hail fell on the sea-level south of lat. 20°—it should have been added, on the western shore of India; it seems not at all uncommon on the eastern shore. A hailstorm occurred at Pondicherry, south of Madras, in 1852, and various other places, if my memory serves me right, which I have not been able to catalogue. Trichinopoly, Masulipatam, and the Gossam Valley, some way from the shore, but nearly on a level with the sea, are mentioned by Dr. P. Thompson, on the authority of Dr. Turnbull Christie and Colonel Bowler.

† Thompson, p. 175.

‡ *Ibid.* 24,962,000 francs.

Kurnaul .... Simla	100 miles apart	3rd May, 1849.
Peshawur	400 miles from Simla	

Probably also at Dacca, where hail showers occurred almost daily during the first week of May.

Ootacamund .... Nursingpore	50 miles apart, 20th March, 1852.
Hydrabad (Sind) .... Delhi	500 miles apart, 17th April, 1854.

On the 16th there was a severe hailstorm at Sattara, 700 miles south of Hydrabad; but I have only coupled together those occurring on the same day.

It must not always be assumed that places are always prone to hail in proportion to the number of hailstorms assigned to them; the *apparent* excess or deficiency of these is not unfrequently to be ascribed to the care or negligence with which they have been recorded. The great seeming predominance of them at Jubbulpore is attributed mainly to the residence for twenty years at that station of Dr. Spilsbury, a faithful, patient, and minute observer in all departments of natural history.

In like manner, when we find hailstorms occurring forty times in twenty-six years, or on an average 1·65 times a year, from 1820 to 1846, and then find that the years 1847, 1848, and 1849 afford us twenty, we must not ascribe the whole, or perhaps any part of this, to change of climate, but to improved registration. On the other hand, again, when we find 1849 affording us fifteen storms, or above three times the number of any of the years around, and when there is no reason why there should have been any change in respect of registry, we may fairly set this year down as having been peculiarly favoured in its falls of hail.

There are four occasions on which remarkable masses of ice, of many hundred pounds in weight, are believed to have fallen in India. One near Seringapatam, in the end of last century, said to have been the size of an elephant. It took three days to melt. We have no further particulars, but there is no reason whatever for our doubting the fact.

In 1826, a mass of ice nearly a cubic yard in size, fell in Khandeish.

In April, 1838, a mass of hailstones, 20 feet in its larger diameter, fell at Dharwar.

On the 22nd of May, after a violent hailstorm, 80 miles south of Bangalore, an immense block of ice, consisting of hailstones cemented together, was found in a dry well.

These masses of ice, like many of those considered hailstones of the largest size, have, in all probability, been formed by violent whirlwinds or eddies, and seem to have reached the monstrous dimensions in which we find them, either on their approach to or their impingement on the ground; and the same thing will apply to those of much more moderate bulk, and which are commonly considered hailstones, though when examined they turn out to be a number of these aggregated together. Many of the masses doubtless owe their origin to being swept, like that of 1852 near Belgaum, into hollows or cavities—in this particular case into a dry well—where they become almost immediately congealed into a mass.

Since 1850 two hailstorms of much greater magnitude, and more disastrous consequences, have occurred than any here made mention of, that in the Himalayas north of the Peshawur on the 12th of May, 1853, when eighty-four human beings and 3000 oxen were killed, and that which occurred at Nainee Tal, a Sanitarium on the lower Himalayas, on the 11th of May, 1855. Of the Peshawur storm we have few details beyond the fact that the ice masses were very hard, compact, and spherical, many of them measuring 3¼ inches in diameter, or nearly a foot in circumference; and this fact seems to have been given from measurement, not by guess.

The description of the Nainee Tal storm, from the pen of an eye-witness of intelligence and information, is the best we possess. The approach of the storm was heralded in by a noise as if thousands of bags of walnuts were being emptied in the air. At first the hail was of comparatively small size, about that of pigeons' eggs; it gradually increased in magnitude, till it reached the dimensions of cricket-balls. Pieces, picked up at all parts of the station, were carefully weighed and measured, and the results will be found further on.

In the unhappy ignorance of the science of meteorology now prevailing around us, it seems generally supposed that these hailstorms are peculiar to India; and many educated persons who have lived long in the country are disposed to receive such narratives as those of the Peshawur and Nainee Tal ice-storms as fabulous, or grossly exaggerated. To correct errors of this sort, and if possible encourage observation, I may refer to Dr. Purdie Thompson's Meteorology, published in 1849, the year before the first collection of Indian hailstorms was laid before the world. He falls into the error of believing them nearly unknown between the tropics.

Form.—The forms of the hailstones which fall in India seem pretty much the same as those that have been examined at home, and they are chiefly of four kinds:—1, pure crystalline masses, either globular or lenticular, internally transparent, but covered externally with a coating of opake white ice; 2, the same, but with a star of many points in the centre, the principal rays of which extend to the circumference, the section being singularly beautiful; 3, nearly globular, consisting of thin concentric layers, like the coatings of an onion, of different degrees of transparency, as if increased in size by film after film being frozen over them in their descent; and 4, agglutinated masses of hailstones, cemented together subsequent to their primary formation—if indeed these last, which may consist in part of any of the previous three varieties, are entitled to the name of hailstones at all.

Size.—I have already stated that we are now no longer required to refer, unless for the sake of familiar comparison, to our hail being as large as pigeon, pullet, or goose eggs, or pumpkins, having abundance of accounts to quote from where it has been correctly weighed and measured, and its precise dimensions put on record. The largest hailstones seem to be from ten to thirteen inches, and to weigh from nine to eighteen ounces. But these are the extreme exceptional cases; and our average maxima appear to be from eight to ten inches in circumference, and from two to four ounces in weight. Their forms are so seldom regular, that it is rarely possible to deduce the one fact from the other.

It is not every one who has the promptitude of the describer of the Nainee Tal storm; but were any one, when a hailstorm occurs, to pick up two or three of the largest pieces, taking care to note the number, and if not provided with a balance of his own, to send the water they have yielded to the apothecary of the station to be weighed or measured, forwarding a note of the result, the cubical contents of the mass might be easily computed, and much valuable information obtained. From the weight of the water it yielded, one of the most important facts connected with it becomes determined, its mass. The fracture of the hailstones when large, with the view to examining, and, if possible, sketching their internal substance, is what should be resorted to as frequently as possible, India affording much greater facilities in this respect than can be looked for elsewhere.

No hailstones have ever been known to fall in India to be compared in magnitude to very many of those already enumerated vaunted blocks of ice, of anything like equal in size to at least a dozen described by Dr. Thompson himself as having fallen in Europe. The great distinguishing characteristic of the Indian, as contrasted with the European hailstorm, is, that with us in the great majority of cases the hail which falls exceeds the size of filberts, at home it seldom amounts to that of peas or beans; that which here is the rule, occurring many times every year, is in Europe the exception—not happening oftener than once in ten or twenty years.

Dr. Buist then describes fifty-one hailstorms, from which the following are selections:—

Hailstorm near Bangalore at Chickanallenhully, on the 22nd of May, 1851.
Lat. 12° 57′, long. 77° 38′. (From the *Bombay Times.*)

On the evening of the 22nd of May, at Chickanallenhully, eighty miles south-west of Bangalore, and forty miles west of Toomcoor, there was a heavy fall of rain, accompanied, after the night closed in, by thunder, lightning, and hail. The hailstones were for the most part about the size of oranges and limes, which broke the tiles on the roofs of houses, and seriously injured cocoanut and beetlenut gardens, and many fruit-trees, crushing many young trees, and breaking down a few larger ones, but neither men nor beasts were injured, all having sought shelter at the commencement of the rain. The next morning many hailstones as large as pumpkins and jack-fruit were found on the plain, extending three miles south of the town; and

one immense block, measuring four and a half feet in length, three feet in breadth, and eighteen inches in thickness, was found in a dry well.

Hailstorm at Kandy (Ceylon) on the 15th of March, 1852.
Lat. 7° 17′ N., long. 80° 36′ E.

Kandy (Ceylon).—"On Monday (15th) afternoon, on a sudden the town assumed a dismal appearance, and heavy showers of rain commenced to fall, accompanied by peels of thunder. The wind blew with such irresistible fury that the branches of some trees towards the Lake Road were broken down to the ground. There was also a fall of hail for nearly an hour, and so much was the curiosity it excited, that crowds of persons were seen, in spite of the rain, busily engaged in picking up the stones, which were as large as bullets. After a few hours the rain ceased, thick clouds that were overspreading the country disappeared, and a fine calm and clear evening followed. The night was quite obscure, and the atmosphere very humid; a star was scarcely to be seen in the firmament, and lightning was flashing from every quarter, illuminating the country, and making the smallest object visible.

Hailstorm at Ootacamund, on the 19th of March, 1852.
Lat. 11° 50′ N., long. 76° 45′. Alt. 7300 feet.

A very severe hailstorm occurred at Ootacamund at 2 P.M. on the 19th of March. The hailstones were not large, but sufficiently so to do considerable damage in the gardens. It lasted about an hour, when the ground was as white as if snow had fallen. Buckets full, caught from the house-tops, were next morning large lumps of ice; but as this is an article little cared for in this cold region, no one took the trouble to keep it. Since this occurred the weather has been much colder, and we cannot as yet throw off any of our winter clothing or blankets.

Hailstorm at Nursingpore, on the 19th and 20th of March, 1852.
Lat. 22° 56′ N., long. 79° 18′ E. Alt. 1900 feet.

A letter of the 30th March, from Nursingpore, contains the following items:—"In my last of the 13th April I mentioned that the weather was extremely sultry, hazy, and suspicious; and I have now to communicate that, from the 17th to the 27th, we experienced a stormy period, of greater intensity and duration than is usually encountered inland upon the sun's equinoctial passage. Rain, more or less, fell on each day, attended invariably with much lightning and thunder, and occasionally with violent gusts of wind. On the 19th, at 2^h 50^m P.M., a fall of hail of the size of ordinary grapes occurred, with lightning and loud bursts of thunder; and on the following day, at 2^h 10^m P.M., a similar phænomenon took place during bright sunshine. No cloud in this instance was to be discerned whence the hail proceeded. No lightning or thunder accompanied this last fall of hail here, and the only body of cloud was at an altitude of about 40° in the south-west quarter. The zenith was quite clear. The total fall of rain amounted to 1·337 inch during the above days."

Hailstorm at Pondicherry, on the 24th of March, 1852.
Lat. 11° 57′ N., long. 79° 54′ E. Alt. 20 feet.

Pondicherry, 24th March.—Pondicherry was visited by a hailstorm between 3 and 4 in the afternoon of Wednesday last (24th), during a squall from the north-east. The hailstones, which fell in large quantities for about 15 minutes, were generally formed of a transparent covering over a white but opake interior, and most of them were flattened or armed with points. The largest might have been an inch and a half in diameter.

Hailstorm at Mahableshwur, on the 16th of April, 1852.
Lat. 17° 56′ N., long. 73° 30′ E. Alt. 4500 feet.

On Friday last, the 16th of April, the weather had become perfectly oppressive in the forenoon, preceded some few days by great piles of thunder-clouds to N.N.E. About 2 o'clock the sky became suddenly overcast, followed by loud claps of thunder and vivid and forked lightning; the thunder increased louder, peal after peal, and lightning flash after flash, until 5 minutes to 4 P.M., when the wind veered round to N.E., and with it came torrents of rain, accompanied by hail, the largest of which was at least the size of a pigeon's egg; such a shower of the latter I cannot recollect ever before witnessing. The entire compound of my house was one sheet of irregular ice—millions of stones might be picked up in a few minutes. This lasted for an hour, and I have since ascertained that the pluviometer indicated the fall of 1·50 inch. During

the same night we had another light shower of some ·06 or ·07 of an inch. Strange, that there was no depression of the barometer; on the contrary, it had risen ·050 of an inch above that of the previous day!

Hailstorm at Poorundhur, on the 11th of December, 1854.
Lat. 18° 42′ N., long. 14° 12′ E. Alt. 3500 feet.

A severe hailstorm was experienced in the Poorundhur Talooka of this Collectorate on the afternoon of the 11th of December. Numbers of persons were severely injured by the falling of large ice-flakes, many of them weighing several pounds, and cattle in considerable numbers have died from the effects of the storm, which, for the time it lasted (about three hours), was the most severe of any within the recollection of the oldest inhabitant. The hailstorm was succeeded, as at Jooneer, by a very heavy fall of rain, and the grain crops, gardens, and fruit-trees have suffered greatly therefrom. Poorundhur is situated at a distance of seventy miles south-east of Jooneer; but we have not yet heard that the intervening districts have experienced similar phænomena to those above described. There has been no particular atmospheric disturbance in or around Poona, the climate of which station is now delightful, as it always is at this time of year.—*Poona Observer,* Dec. 20.

The most unusual occurrence of a hailstorm in Ceylon has lately taken place. A few days since at Puselava, following a thunder-storm, a heavy fall of hail took place, lasting half an hour. In some places, where the wind drove the hail into corners, whole handsfull of hail, the size of marbles, were gathered. The natives were struck with wonderment, and whilst shifting the frozen drops from hand to hand, declared that it was so *hot* that they could not hold it. The hail actually for some minutes whitened the ground in many places. At Hunasgeria also a shower of hail fell on the same day, but not in the same quantity as at Puselava. Some years ago we saw a small fall of hail at Kornegalle. It is unknown either at Newera Killia or at the Neilgherries.—*Ceylon Times,* April 13.

Hailstorm at Futtehgurh, on the 21st of April, 1855. Lat. 26° 10′, long. 75° 10′.

A correspondent at Futtehgurh, writing on the 24th of April, mentions the occurrence of a severe hailstorm on Saturday last, which had caused considerable damage to the tobacco and melon fields. Our correspondent says the hailstones were larger than he ever beheld; one he measured being seven inches in circumference. Heavy clouds were hanging about at the time of writing.—*Delhi Gazette,* April 26.

A correspondent gives the following account of a hailstorm which took place at Futtehgurh on the 21st April:—"Last Saturday we had an awful hailstorm, such a one as probably has not been known for a century. The hailstones, without exaggeration, were larger than turkey eggs, and sufficient to have knocked a bullock down. As they fell, you saw them rebounding six feet in height."

Hailstorm at Nainee Tal, on the 11th of May, 1855. Lat. 29° 20′, long. 79° 80′.

On the 11th of May 1855, Nainee Tal was visited by a storm of hail, which, as regards the size, weight, and number of the stones, has probably never been surpassed by any in the world. A calm, cool morning; a hot, enervating noon; a cold evening and night, with the wind blowing bleakly from the north, had characterized the few preceding days. The barometer had stood high, and the wet-bulb thermometer indicated an extremely dry atmosphere. On the 10th, at 4 P.M., the dry-bulb thermometer stood, under a grass chopper, at 80 degrees Fahr.; on the 11th, at the same hour and place, at 62 degrees Fahr.! On the former date, the difference between the dry- and wet-bulb thermometers was 15 degrees; on the latter, this difference was reduced to 4 degrees! Towards 6 P.M., a small preliminary shower of rain fell, deep-toned thunder rolled and reverberated, and vivid lightning streamed and blazed over the devoted station. The hail was ushered in by a few bright lens-shaped stones, as large as pigeons' eggs; then came more. Many were the weighings and measurings of these monsters over all parts of the station. Some weighed 6, others 8, others 10 ounces; and one or two more than $1\frac{1}{2}$ pound avoirdupois, with circumferences varying from 9 to 13 inches. Though no bullocks were killed, a monkey was, and three human beings were knocked down. Birds were killed, trees barked, and houses unroofed. Such was the storm of the 11th of May, and it forms an epoch in the meteorological history of Nainee Tal; for though hail is common enough here in the hot weather, no stones (during the ten years that Sir

W. Richards has kept a register) of any size have ever fallen except once, and then they were only $2\frac{1}{2}$ inches in circumference. The stones measured from 1 to 14 inches about.

What is a Hailstorm?—Aqueous vapour condensed into ice, by passing through an intensely cold atmosphere, is the apparent, and probably the true answer. Some contend, that, because hail falls so rarely in winter, and the cloud whence it comes is usually at no great altitude, there being at the same time almost always thunder and lightning (with atmospheric electrometers changing in intensity), and passing from positive to negative, and *vice versâ* (ten times in a minute), hence electricity must have quite as much to do in the matter as cold. But the latter seems the most reasonable view. In almost all very large hailstones (as was observed here) is found a nucleus, a piece of snow, or a small opake hailstone in the centre, surrounded by transparent coverings, one over another, concentrically arranged (like an onion), leading to the belief that the first concretion was a small one, and that it *accumulated* in its descent; that a whirlwind above kept battering these formations together, and prevented their falling, until at length, immensely enlarged, and getting out of this influence, they came down upon *terra firma*. We are not justified in assigning limits to the amount of cold in the upper strata of the atmosphere.

On a Rainbow seen after Sunset. By the Rev. Professor Chevallier.

At the meeting of the Association in 1849, an account was given of a rainbow seen after actual sunset (Report, p. 16); and it was suggested that, in order to account for it, either the horizontal refraction must have been much greater than its ordinary value, or the rainbow must have been formed in a very elevated region of the atmosphere.

On August 11, 1855, a rainbow was seen at Whitby, by Mr. C. P. Knight, which seems to show that such a phænomenon may arise from rain falling at a great height. The mean Greenwich time of the apparent setting of the sun's upper limb, taking refraction into account, was $7^h\ 44^m$.

At $7^h\ 30^m$, "*railway time*," a rainbow was seen, and continued to be visible till $7^h\ 48^m$, which is thus described. "It appeared to be far above the earth's surface. It was higher up than some clouds called cirro-stratus (in a sketch which accompanied the account); and those clouds were seen in front of the bow in several places. Rain-clouds were some distance below these, and far above all were some filmy light cirri, lit up by the sun. There were only two or three small spaces of blue sky to be seen. No rain had fallen for some hours; and there was no appearance of any falling where the bow was. The time I had was Greenwich time."

Although the time given may not be quite accurate, it seems to be established that this rainbow was seen after actual sunset, and that it was formed in an elevated region of the atmosphere.

Improvements on a Dew-point Hygrometer lately described by the Author. By Professor Connell, *F.R.S. L. & E.*

This instrument consists of a little bottle of thin brass, polished externally, connected laterally with a small exhausting syringe, and having a thermometer inserted in it, by means of an air-tight brass stopper. Ether having been previously introduced into the bottle, the temperature is gradually reduced by working the syringe until moisture is deposited on the bottle. The thermometer then indicates the dew-point. An intercepting portion of ivory prevents the communication of the heat of friction to the bottle. The valves of the syringe are constructed of gold-beaters' leaf.

A few simple changes, since the instrument was described in the Transactions of the Royal Society of Edinburgh and in the Philosophical Magazine for 1854, have greatly facilitated its manipulation, and have made it less liable to injury.

The brass bottle is now connected with the syringe by means of a coupling screw instead of a common screw. This permits the bottle with the inserted thermometer to be at once brought into the proper vertical position, whatever be the nature and situation of the fixture to which the clamp, by which the instrument is secured when in operation, is attached. The projecting portion of the ivory intercepting partition is now made of brass, and is therefore not liable to fracture as it was previously. The form of the key employed in screwing and unscrewing the parts of the instru-

ment, has now been so altered as not to cause any injury when made use of, as it sometimes did previously.

It was found in a late tour on the continent that no part of the instrument is liable to injury from the ordinary concussions of travelling; and its use was ascertained to be as well adapted to continental climates, so far as was tried, as to that of Great Britain.

Wind-charts of the Atlantic, compiled from Maury's *Pilot Charts.* *By* Captain FitzRoy, *R.N., F.R.S.*

These diagrams are intended to show what winds prevail, at the four quarters of the year, in the Atlantic.

Each figure should be considered by itself alone, as the scales are generally very different, depending on the number of observations from which the respective diagrams are constructed.

Relative prevalence of wind (or calm) is shown in each square of ten degrees; but in no case is *absolute* amount given; nor is *strength* of wind exhibited, as it may be hereafter.

The navigator may be influenced, in shaping a course, by the probability of finding certain winds more or less favourable in certain localities.

To a sailing ship such considerations are most important; and a glance at these charts shows a seaman how the wind blows (usually) during a *season*, as readily as his "dog-vane" indicates the (apparent) direction at any *moment* of observation.

The diagrams illustrate Maury's *Pilot* Charts, in which similar information is offered by numbers, which require more mental operation in their use than these graphical figures.

In each square the numerical data contained in four of Lieut. Maury's five-degree squares are combined in the following manner.

Of a circle inscribed in any such square, the radius is taken as a measure of the sum of the greatest number of observations of the most prevalent wind; and other lines, likewise drawn (to leeward respectively) from the centre, and on the same scale, indicate the *relative* duration or prevalence of other winds (each observation referring to a period of *eight hours*), and through the extremities of these lines a boundary is traced.

As a circle is said to be generated by the revolution of a line around a point, so the figure representing successive directions of wind may be supposed to be generated by the motions of a wind-vane, and the lines or points may extend from the centre (like the growth of crystals) in proportion to the *persistence* (or continuance) of the vane in their respective directions.

The *relative* amount or duration of calms is shown by a circle, of which the radius equals (according to the scale of the diagram) the number of (eight-hour) periods in which there was little or no wind.

The direction of wind is corrected, approximately, for variation of the compass.

The larger area of each figure is to leeward of the centre of the square (or inscribed circle).

The calendar quarters of the year are adopted advisedly, because the consideration of seasons in all quarters of the globe, and the examination of Maury's charts (including those of the trade-winds), induce the belief that extreme periodical changes of wind follow at a certain interval, rather than accompany the extremes of temperature or climate.

The small figures at the lower left-hand corner indicate the total number of (eight-hour) observations of calm, as well as of wind, recorded as having been made in that square; and the figures at the lower right-hand corner show, in decimals of an inch, the *unit of scale* employed in constructing the diagram *in that square*.

The force of wind is not shown, because it was not noted in the records from which these charts were compiled; but at a future time it may be given so combined and arranged as to indicate average strength as well as direction.

Nothing more is thus shown, in *a graphical manner*, than has been exhibited *numerically* in Maury's original *Pilot* Charts, whence solely the data for these were obtained.

For the few squares still blank, sufficient data have not yet been collected.

The number of observations used in constructing each diagram affords a scale of

value for the figure, which may be augmented from time to time by fresh material, but need not be diminished, unless by a reduction of the *scale* (should the figure much outgrow its square).

The star-like form of the figures ("Wind-star") is merely a consequence of *grouping* observations under *principal* points of the compass.

It is proposed to compile wind-charts for all known parts of the world, for smaller spaces or squares, and for each month of the year, as soon as sufficient observations can be collected and employed.

On the Detection and Measurement of Atmospheric Electricity by the Photo-Barograph and Thermograph. By M. J. JOHNSON, *M.A., Radcliffe Observer, Oxford.*

Photography has already rendered considerable aid to science, and some results brought before the Section by Mr. Johnson furnish an example of this. On examining and comparing the registrations of the thermometer and barometer, certain peculiarities present themselves which indicate a curious connexion between the course of these instruments and the state of the weather. The line which indicates the daily curve of temperature is sometimes serrated, sometimes even and continuous; and these appearances correspond to certain determinate states of the weather; the serrated outline being confined to fine warm weather, from the end of March to the end of September, and never occurring even then during the night. Among the most remarkable results is a sudden rise of the barometer, amounting to ·035 inch, and an increase of temperature of 1°, coincident with the occurrence of a thunder-clap which struck one of the churches in Oxford, July 14, 1855. A similar phænomenon took place during a thunder-storm on the 23rd of August, when the rise of the barometer was still greater, amounting to ·049 inch; though the thunder-clap coincident with this latter rise was distant. Mr. Johnson also showed, that, during every occurrence of thunder or hail which had been recorded by his instruments, similar phænomena presented themselves, sometimes very minute, but quite perceptible.

Force of the Wind in July and August 1855, *as taken by the "Atmospheric Recorder" at the Beeston Observatory. By* E. J. LOWE, *F.R.A.S. &c.*

The instruments at the Beeston Observatory have only recently been erected; yet as the records of the force of the wind show some interesting facts, the following brief summary has been forwarded to the British Association in the belief that the records will prove interesting.

Hour.	Number of days quite calm.		Mean pressure in oz. on the square foot.		Greatest pressure in lb. and oz. on the square foot.	
A.M.	July.	August.	July.	August.	July.	August.
h m						
12 0	26	19	0⅓	1	0·5	1·7
12 30	26	19	0⅓	1	0·4	0·5
1 0	26	18	0½	1	0·6	0·8
1 30	26	19	0⅓	1	0·4	1·4
2 0	26	19	0⅓	1	0·8	0·8
2 30	26	19	0⅓	2	0·4	1·10
3 0	26	18	0⅓	2	0·5	1·7
3 30	26	19	0⅓	2	0·4	1·12
4 0	26	19	0⅕	1	0·3	0·7
4 30	25	19	0⅓	1½	0·3	1·6
5 0	25	19	0⅓	1½	0·7	1·2
5 30	25	19	1	1½	1·5	1·5
6 0	25	19	1	2½	0·7	1·9
6 30	24	19	1½	3	1·5	1·12
7 0	23	18	1½	4	1·5	2·13
7 30	22	16	2	5	1·6	1·14
8 0	21	15	2½	5	1·6	2·14
8 30	20	14	2½	7	1·6	3·3

Hour.	Number of days quite calm.		Mean pressure in oz. on the square foot.		Greatest pressure in lb. and oz. on the square foot.	
A.M.	July.	August.	July.	August.	July.	August.
h m						
9 0	18	13	3	8	1·10	2·13
9 30	16	9	3	8	1·6	2·13
10 0	16	8	3	8½	2·3	2·13
10 30	15	8	3	8½	1·6	2·13
11 0	13	8	3	9	1·7	2·14
11 30	12	7	3	9	2·0	2·6
P.M.						
12 0	11	7	3	9	1·10	2·12
12 30	9	5	3	9	1·10	2·12
1 0	8	4	3½	11	1·13	2·11
1 30	7	4	3½	12	1·14	2·0
2 0	6	3	3½	8	1·10	2·0
2 30	5	3	4	9	1·11	2·12
3 0	4	3	3½	8	1·12	1·14
3 30	3	3	3	7	1·3	1·13
4 0	5	4	2	9	2·0	1·13
4 30	6	4	3	7	1·14	1·12
5 0	7	6	3½	5	1·3	1·12
5 30	8	10	2½	4	1·7	1·7
6 0	9	11	2½	3½	1·4	1·6
6 30	10	13	2	2½	0·8	1·5
7 0	12	14	1½	2½	1·6	1·8
7 30	13	15	1½	2½	0·8	1·8
8 0	16	16	1	2	1·3	1·5
8 30	16	16	0½	2	0·3	1·6
9 0	17	16	0½	3	0·4	1·13
9 30	18	16	0¾	2	0·4	1·7
10 0	21	17	0½	1½	0·4	1·5
10 30	22	17	0½	1	0·4	0·8
11 0	23	19	0½	1½	0·4	1·6
11 30	24	19	0½	2	0·5	1·7

From the above it will be seen that in July the greatest number of calm days occurred between midnight and 4 A.M., and the least number at 3^h 30^m P.M.; and in August the greatest number from 11 P.M. to 6^h 30^m A.M., and the least number from 2 P.M. to 3^h 30^m P.M.; also that in each month there was a gradual increase from the minimum to the maximum number.

The mean pressure in July was least from 12^h 30^m A.M. to 5 A.M., and greatest at 2^h 30^m P.M., and in August least from 12 A.M. to 2 A.M., and greatest at 1^h 30^m P.M.

The greatest pressure was heaviest in July at 10 A.M. and in August at 8^h 30^m A.M. The greatest pressure was least in July between 8^h 30^m P.M. and 4^h 30^m A.M., and in August at 12^h 30^m A.M.

In July the range of calm days was from 3 to 26, *i. e.* 23, and in August 3 to 19, *i. e.* 16. The range in mean pressure was in July from about 0⅓ oz. to 4 oz., or 12 times as strong; and in August from 1 oz. to 12 oz., or 12 times as strong. The greatest force in July ranged between 3 oz. and 2 lbs. 3 oz., an increase of 12 times; and in August between 5 oz. and 3 lbs. 3 oz., an increase of 10 times the force.

Singular Iridescent Phænomenon seen on Windermere Lake, Oct. 24, 1851. *By* J. C. Mounsey. *Communicated by* J. F. Miller, *Ph.D., F.R.S. &c.*

The morning was very misty, and the barometer high (30·35 at Whitehaven). Between 10 and 11 A.M. the mist cleared off, the sky became cloudless and the air calm, the lake being of a glassy smoothness. At 11, we went on the lake, and in

about half an hour I observed brilliant prismatic colours on the water near the shore, say half a mile or more distant, but no appearance of a bow. I rowed towards the spot, and, in doing so, the colours increased in extent and brilliancy. There were two bows, which resembled ordinary rainbows inverted; both were exceedingly brilliant at the extremities, and became gradually fainter as they receded from the shore. The outer bow came completely down to the boat, which appeared to prevent our seeing the crown of the arch; its extremities also proceeded from the shore, and its centre was apparently under the feet of the spectator. In both bows the red was on the outside and the violet on the inside, and, in both, the light and colours were most brilliant and distinct at the extremities, or points of convergence at the water's edge. I am certain there was no rainbow in the sky at the time, neither was there any solar halo or other phænomenon in the air that I observed, of which this could be the reflexion.

I observed that, wherever the prismatic phænomenon showed itself, there was a sort of scum on the water, as though there was some fine dust or bubbles on the surface. I put my finger into the water, and found it so dirty as to leave a distinct mark behind, which leads me to think that what I at first took to be small bubbles must have been some sort of dust. Whatever it was, it appeared to me to be the cause of the iridescence, as, wherever it was lost, the bows disappeared. The bows were visible about an hour, and, in looking at them, the sun was of course behind the spectator.

The boatmen say they have sometimes (though very rarely) seen a similar phænomenon after the disappearance of a mist from the surface of the water. At Whitehaven the sky was also cloudless, but in the evening the air was misty.

In reply to questions from Prof. Powell, some further particulars were stated and drawings furnished.

Notice of Climatological Elements in the Western District of Scotland. By Dr. Nichol.

Meteorological Phænomena for 1854, *registered at Huggate. By the* Rev. T. Rankin.

On the Aurora Borealis. By Rear-Admiral Sir John Ross.

Referring to his formerly published opinion, namely "that the phænomena of the aurora borealis were occasioned by the action of the sun, when below the pole, on the surrounding masses of coloured ice, by its rays being reflected from the points of incidence to clouds above the pole which were before invisible," the author stated his impression that the phænomena might be artificially produced. To accomplish this, he placed a powerful lamp to represent the sun, having a lens, at the focal distance of which he placed a rectified terrestrial globe, on which bruised glass, of the various colours seen in Baffin's Bay, was placed, to represent the coloured icebergs seen in that locality, while the space between Greenland and Spitzbergen was left blank, to represent the sea. To represent the clouds above the pole, which were to receive the refracted rays, he applied a hot iron to a sponge; and by giving the globe a regular diurnal motion, he produced the phænomena vulgarly called "The Merry Dancers," and every other appearance, exactly as seen in the natural sky, while it disappeared as the globe turned, as being the part representing the sea to the points of incidence.

On the Meteorology of the United States and Canada. By R. Russell.

The author first drew attention to the physical geography of North America, as influencing in a very particular manner the meteorological phænomena of that country. The Appalachian chain, from Northern Alabama to Maine, runs parallel with the

Atlantic coast, and though only from 2000 to 4000 feet in elevation, exercised a marked influence in giving peculiar development to certain atmospheric disturbances which took place in the Atlantic States. To the west of this chain lies the vast valley of the Mississippi; its surface forms an easy ascent towards the Lakes of about one foot in a mile. This great basin is thus exposed to the free course of the south winds from the Gulf of Mexico. But the Rocky Mountains on the west, stretching from the Arctic Circle, appear to be the grand physical feature which in a great measure determines the peculiarities of the meteorology of North America. This range has an average elevation of 10,000 to 12,000 feet, which is almost unbroken to the Isthmus of Panama. This vast natural wall forms a barrier to the trade-winds of the Caribbean Sea, as they cannot cross this ridge and flow into the Pacific. By means of this elevated land, which forms the isthmus connecting the two continents, the trade-wind is gradually directed northwards until it reaches Texas as a south wind, which is the prevailing one in that State throughout the year, but more especially in summer. The great fertility of the climate of the United States and Canada is to be chiefly ascribed to this physical feature of the country. The flow of the south wind in winter brings moisture and mild weather—in summer intense heat, with thunder-storms. The wind, which is entirely opposite in its character to the south, is the west. In winter, a due west wind is intensely cold over the whole territory of Canada and the United States, and it often blows with great violence: there is no relaxing of the cold weather so long as it continues. In summer it is dry, and the sky assumes that bright azure tint which is so striking to one from our island. It is a singular fact, that a west upper current flowing across the Rocky Mountains seems to prevail almost constantly during the whole year. This must never be lost sight of in discussing the atmospheric phænomena of North America. The upper current is nearly due west at Washington and the States to the south; it is a point or two north of west in the New England States and Canada. The west and north-west wind of the United States must be regarded as the descent of this upper current. In fact, the winds of the United States, especially during great atmospheric disturbances, may all be considered to become modifications of the south and the west wind. The indications of the thermometer and hygrometer are entirely in favour of this arrangement. The N. and N.W. winds must be regarded as modifications of the upper westerly current descending to the surface of the ground, and the S.W., S.E., E., and even N.E., as modifications of the south wind. The difference betwixt the temperature of the Arctic current and the Gulf-stream, as they meet beyond the Newfoundland coast, is not nearly so great as the difference of the temperature, in winter, between the west current which descends along the eastern slopes of the Rocky Mountains, and the south wind from the warm waters of the Gulf of Mexico. The vast territories of the United States to the east of the Rocky Mountains are subjected alternately to these two currents so opposite in their characters, and hence the great changeableness of the climate, to which we have nothing that can be compared in Europe. The exceeding coldness of the west wind arises from its being robbed of its moisture as it crosses the Rocky Mountains. It is especially worthy of being kept in mind, that the west wind, or its modifications, is light and pleasant in the warm season, but intensely cold in winter, and blows with great vehemence when it succeeds the south wind. After the west wind has blown for some time in winter, the whole area over which it has extended is subjected to a great depression of temperature. As a general rule, the temperature rises in the far west in winter for some time before it rises in the Atlantic States. The weather first moderates in the territory east of the Rocky Mountains and west of the Mississippi, by a south wind, 500 to 700 miles in breadth, setting in and blowing along the eastern slopes of the Rocky Mountains, and probably extending into the Arctic Circle. The rise of temperature thus takes place over all the regions swept by the south wind. The rising of temperature is apparently propagated from west to east in the United States, by the south wind flowing in succession over those States which are more easterly. This is the cause of the winter storms of the United States travelling from west to east, as has been maintained by Prof. Espy, who was the first that made the discovery, and which has since been corroborated by Profs. Hare and Loomis. The distance between the ridge of the Rocky Mountains and the east coast of Florida is about 1400 miles, but in the latitude of Newfoundland the Rocky Mountains

are nearly double that distance from the Atlantic. The south wind perhaps never occupies at one time the whole breadth of the country from western Texas to eastern Florida. The south wind is rapidly propagated from the west along the northern shores of the Gulf of Mexico, but it is almost as rapidly destroyed on its western edges by the cold upper current descending along the eastern slopes of the Rocky Mountains, and penetrating, as a surface wind, this warm current from the Caribbean Sea. In this manner the western edges of the south wind are raised into the upper current, and drifted towards the east. Thus the winter storms of the United States are always succeeded by a cold wind from a westerly direction. The cause of the violence of the west wind in winter was then shown. The weather during summer was regulated by the same principles, but the north-west wind then lost its power, in consequence of its being warm and elastic. The thunder-storms and tornadoes generally drifted from west to east in the middle States, and from north-west in the northern States. This arose from the clouds being formed in the upper current, and drifting towards the east at the very time that the south wind was prevailing. The thunder and tornado clouds usually drifted in the south wind over the States bordering on the Gulf of Mexico. The hurricane-clouds also drifted in the southern stream of warm air, and were often propagated along the Atlantic coast. The fluctuations of the barometer were attributed to the fluctuations of density of the air at the surface of the earth. This was Dalton's hypothesis, which he thought explained the fluctuations of the barometer more consistently than any which had been offered. It did not explain all in Britain, but it explained a great deal,—the apparent exceptions were all grouped together very consistently. The height of the barometer is inversely as the temperature, or rather moisture, for the latter is a more permanent cause of high temperature. Diagrams were exhibited to illustrate this connexion between the rise or fall of temperature and the fall or rise of mercury. By adopting the arbitrary scale of 5° of heat as equal to one-tenth of an inch of mercury, which indicated the south wind to be about 10,000 feet in height, a great parallelism between the curve of temperature and inverted curve of the barometer was exhibited. A more perfect explanation of the fluctuations of the barometer at Alabama could not be given. The south wind being lighter, depressed the barometer at every place where the temperature was raised. The low barometer extended in a long line from the Gulf of Mexico to the lakes, and travelled to the east as the rains and high temperature did. The grand exception to fluctuations of the barometer being occasioned by fluctuations in the density of the air at the surface of the earth, arises in the West Indian hurricane, when a depression of two inches was sometimes observed to take place. The only theory which successfully met this phænomena was that of Prof. Espy, in which the wind blowing towards a central space rose in consequence of the extrication of latent caloric, by the condensation of moisture through the expansion of the air causing a reduction of temperature below the dew-point. Prof. Espy maintains that the whole force generated during hurricanes can be accounted for by the effects of heat,—Prof. Hare, that part is due to the electrical agency. In the case of the sea-breeze, a considerable body of air is put and kept in motion by slight differences in the weights of adjoining columns of air. Were such differences of the atmospheric conditions as the chart of the 10th of November exhibited between the mouth of the Mississippi and Montreal, tremendous disturbances would ensue. When the distance is great, the power is diffused in moving the whole body of air betwixt the stations. The expenditure of power in this diffused manner may be compared to the flow of the Mississippi over the last 1400 miles of its course, where the fall is less than three inches to a mile. On the other hand, when the Niagara tumbles over its great precipice, it expends much power at once. The hurricane might be regarded as an aërial cataract, only the air being forced upwards. If a slight fall of rain produced such remarkable effects as are noticed on the passage of the squall cloud, what must be the power evoked by the evolution of latent caloric in hurricanes! Six inches of rain have been known to fall during some hurricanes. The caloric set free by the condensation of this amount of water over every square mile is equal to that which would be generated in the burning of 2,620,000 tons of coal, allowing 1 lb. of coal to evaporate 13 lbs. of water. The clouds of the hurricane interrupt the ominous calm as suddenly as the smooth flow of the stream is changed at the brink of the cascade.

On Naval Anemometrical Observations. By Professor C. Piazzi Smyth.

After alluding to the mechanical importance of the trade-winds in the economy of the atmosphere, the author pointed out the naturally admirable circumstances of a station on the surface of the sea for making exact observations to this end; but indicated also the artificial difficulties that were opposed by the eddies caused about the actual station, viz. the deck of a ship, as well as by its proper motion. From a series of observations communicated to him by Captain H. Toynbee, the author had concluded, that the only unexceptionable station for anemometrical observation at sea was the *mast head*. Accordingly he exhibited a combined apparatus for the direction and the velocity of the wind, arranged with a view to such a position, and also with a view to accurately observing the *mean* effects, and this, by a summation of every individual gust, even the lightest. For the most accurate plan of securing data, he had arranged a method of electric registration which was extremely simple, and proceeded in the cabins below while the anemometers were measuring the wind aloft.

Notices of Rain-falls for a Series of Years at Home and in Foreign Countries. By P. L. Simmonds.

After pointing out the advantages which would result from an accumulation of facts that would serve to guide us to a knowledge of the mean average fall of rain in certain periods, the proportionate evaporation, and the alternation of wet and dry seasons, Mr. Simmonds pointed out the value of such inquiries to the agriculturist, the physician, and the statist; and showed how important was this knowledge of the mean annual fall of rain in particular localities, and the average number of days in which rain fell in the year. Particular crops, as the sugar-cane, the indigo-plant, the cotton- and tobacco-plants might be entirely ruined by too much or too little rain. Many localities, such as Malta, Gibraltar, Ascension, &c., are obliged to husband the rain-water in tanks. The navigation of rivers and the irrigation of adjacent lands are also dependent on a certain amount of rain; and the potato, the vine, and other plants are injuriously affected by the condition of the atmosphere and the superabundance of moisture. Even the fact of whether the moon has any influence on the fall of rain is still a disputed point.

The relative proportions of rain that fall by night and by day was another point touched on. Mr. Simmonds then took a survey of the records of this branch of meteorology in the various quarters of the globe, citing the comparative falls of rain in the tropics and in temperate regions in different countries.

On Waterspouts. By Dr. Taylor, *Professor of Natural Philosophy, Andersonian University, Glasgow.*

The author, after describing the phænomena of the Waterspout, stated the different theories which had been proposed as to their nature and origin, and showed that the only one which, in the present state of science, is at all tenable, is that which ascribes the descent of the cone of cloud and the ascent of water or other substances, to the partial vacuum created in a portion of the atmosphere by the action of contending currents producing a whirlwind. He next pointed out the difficulties encountered in applying this theory to the explanation of some of the phænomena, such as the division of the "tube" into several portions towards its lower part, which are often seen to twist about each other like coiling snakes, and also to present the appearance of a dilation running up the tube like the action of the throat of an animal in drinking. After showing, by calculation founded on the laws of dynamics, that the rapidity of rotatory movement necessary to produce any considerable approach to a total vacuum in the interior of the tube cannot possibly exist in any case, it was proved that a shred of cloud, of slightly less specific gravity than that of the atmosphere below it, might easily be made to descend by a comparatively slight degree of rotatory rapidity; and also that spray from the sea or light bodies from the

earth, might be carried up into the interior of the revolving mass to an extent sufficient to account for all the appearances which have in any case been actually observed. Formulæ were shown giving the necessary velocity in any supposed case. An experimental apparatus was next exhibited, whereby the appearances of the waterspout can be easily and completely produced on a small scale. A rectangular box, about 18 inches square, formed of plates of glass, placed merely edge to edge at the corners, but not cemented, is covered by a plate of glass with a hole about 1½ inch in diameter in the centre of it. This box is suspended to the roof by means of a twisted string, and the interior filled with the smoke rising from burning nitrated paper. A film of loose cotton wool is placed on the opening in the lid, and the box set into rotation. In a short time the air enters at the opening as the smoke is pressed out by the centrifugal action at the edges of the plates, and a tube exactly resembling the waterspout descends in the interior. It frequently divides into two, three, or more tubes which coil round each other; and as their shreds, often of a flat or spiral form, turn themselves in different positions to the eye, the appearance formerly referred to, of a drinking action, is exhibited. Small holes pierced in the bottom, allowing air also there to enter, give rise to the formation of an ascending column which meets and joins with the descending one, precisely as on the great scale in nature.

CHEMISTRY.

On the Polar Decomposition of Water by Common and Atmospheric Electricity. By THOMAS ANDREWS, *M.D., F.R.S., M.R.I.A.*

IN the fine experiment first made by two Dutch chemists, and afterwards modified and extended by Wollaston, water was decomposed by a succession of disruptive discharges produced by the common electrical machine. But in this experiment, as Wollaston himself has correctly remarked, we have only an imitation of the galvanic phænomena, and the essential differences between its results and true electro-chemical decomposition have been pointed out by Faraday with his usual clearness and ability. "The law which regulates the transference and final place of the evolved bodies," the latter remarks, "has no influence here. The water is evolved at both poles, and the oxygen evolved at the wires are the elements of the water existing before in those places."

The same distinguished experimentalist obtained only uncertain results when he attempted to procure the true polar decomposition of water by common electricity, that is, to decompose it so that the oxygen might be evolved at one pole and the hydrogen at the other. "When what I consider the true effect only was obtained," he says, "the quantity of gas given off was so small that I could not ascertain whether it was, as it ought to be, oxygen at one wire and hydrogen at the other. Of the two streams, one seemed more copious than the other; and on turning the apparatus round, still the same side in relation to the machine gave the largest stream. But the quantities were so small, that on working the machine for half an hour, I could not obtain at either pole a bubble of gas larger than a grain of sand."

On repeating this experiment with wires of different lengths and thicknesses, I obtained the same uncertain results, although I had at my command a stream of electricity of great power, and which could be maintained without intermission for many hours. But while engaged in some experiments on the conversion of oxygen, contained in fine thermometer tubes, into ozone, the tubes being inverted in water, I found to my surprise that the gas in certain cases steadily augmented in volume, and on further inquiry I found that the augmentation of volume arose from the water having undergone polar decomposition. The conditions under which the gases arising from the polar decomposition of water might be obtained were now quite manifest, as was also the cause of no appreciable amount of gas having been obtained in former investigations. The quantity of gas produced in fact in a given time from the electrolysis of water, by means even of a powerful electrical machine, is so small, that the

gases are dissolved in the liquid as quickly as they are formed, if the poles, whether they be large or small, be freely exposed to the action of a large mass of the liquid; but if the bulk of liquid around each pole be made to correspond to the volume of the gases evolved, the latter will not be dissolved to a greater extent than in ordinary eudiometric experiments conducted over water. To attain this object it is only necessary to employ thermometer tubes, having fine platina wires hermetically sealed into their upper ends, as the tubes for receiving the gases. The wires may be so long as to extend through the entire length of the thermometer tubes; but it will be sufficient if they only project a short way into the tubes, as the film of liquid which covers the interior of the tube is sufficient to conduct electricity of such high tension as that produced by the electrical machine.

That the gases were evolved very nearly in the proportion of 1 vol. oxygen to 2 vols. hydrogen, will appear from the following examples:—

Hydrogen.........	6·85	4·00	3·35
Oxygen...........	3·45	2·10	1·55

The electrolyte employed in these experiments was water containing 1 per cent. of sulphuric acid. The gases collected in these tubes were thus proved to be oxygen and hydrogen:—

1. Electrical sparks passed through the hydrogen tube exhibited the characteristic red colour which electrical flashes produce in that gas.

2. On introducing a solution of iodide of potassium into the oxygen tube, and passing sparks through it, the oxygen was converted into ozone, and absorbed in the course of about one minute.

3. On reversing the connexions with the electrical machine and the ground, the relative volumes of the gases were reversed; and after passing the current for the same time as before, and afterwards a spark through the mixed gases, they combined together in both tubes with explosion.

Each of the above divisions contained 0·00006 cent. cub., and an electrical machine, in good order and performing 240 revolutions each minute, produced about 1·1 division of oxygen gas in the same time. A column of acidulated water, 10 feet long, and having a section equal to the internal calibre of a fine thermometer tube in which it was contained, presented no sensible resistance to the passage of this current; but a similar column of distilled water 1 foot in length reduced the current to $\frac{1}{8}$th of its original amount.

On passing the electrical current through a series of sixty pairs of thermometer tubes charged with acidulated water, and fitted with platina wires as already described, decomposition proceeded with the same facility, and the same amount of oxygen and hydrogen was collected in each pair of tubes as when only a single couple was interposed in the circuit.

The same apparatus enabled me to decompose water without difficulty by means of atmospheric electricity. To collect the electricity, I employed an electrical kite which carried a fine brass wire attached to its cord. The experiments were all performed on fine clear days, when the air exhibited no unusual symptoms of free electricity. On connecting the platina wire of one of the thermometer tubes with the insulated wire of the kite, and that of the other tube with the ground, the decomposition proceeded slowly but steadily at the rate of 0·9 div. or about 0·000054 cub. cent. oxygen per hour. Hence about 0·000000085 gramme water was decomposed hourly, or nearly $\frac{1}{10000000}$ gramme, or $\frac{1}{700000}$ of a grain. The wire of the kite gave small sparks, varying in length according to the amount of movement in the kite, from one-tenth to half an inch in length. The shocks were moderately strong; and the needle of a galvanometer of 2000 coils was sensibly deflected.

In the Philosophical Transactions for 1831, Mr. Barry describes an experiment, in which he supposes that he collected the gases produced by the decomposition of water by the action of atmospheric electricity; but from the form of apparatus which he employed, I consider it very improbable that he could have succeeded in collecting any visible quantity of either of the gases.

On the Allotropic Modifications of Chlorine and Bromine analogous to the Ozone from Oxygen. By THOMAS ANDREWS, *M.D., F.R.S., M.R.I.A.*

The author explained that ozone could be produced, first, by an electric spark; secondly, by the decomposition of acids and solutions, when coming into contact with the galvanic wire; and lastly, by oxidation.

On Photographic Researches. By Mr. BARNETT.

Photochemical Researches, with reference to the Laws of the Chemical Action of Light. By Professor BUNSEN *of Heidelberg and* Dr. HENRY E. ROSCOE *of London.*

The following abstract gives the results of an investigation extending over a period of nearly two years, which has been carried on at Heidelberg.

Owing to the great experimental difficulties which are met with in researches on the chemical action of light, our knowledge of the laws which govern this action is at present very limited. The object of the following investigation was to endeavour to obtain more precise information regarding these laws, and if possible to arrive at a quantitative measurement of the chemical rays. The first substances examined in their photochemical relations were aqueous solutions of chlorine, bromine, and iodine, either alone in solution or mixed with hydrogenous organic substances, and the alteration which these solutions underwent by exposure to sun-light was made the subject of accurate measurement. The amount of free chlorine, bromine, or iodine present both before and after insolation, was estimated most exactly by the iodometric method, and the experiments were so conducted that all errors arising from gaseous absorption or diffusion were fully eliminated. From many experiments made according to this method, it was observed that no simple relation existed between the amount of free chlorine which disappeared and the time of exposure or the intensity of the light.

This anomalous action may be explained by theoretical considerations. Chemical affinity must be regarded as the resultant of all the forces which come into play during the decomposition, and therefore the total action is dependent not only upon the interchanging molecules, but also upon the atoms which more or less surround these. Alteration in the mass of these surrounding particles must therefore alter the resulting chemical action. The correctness of this view was remarkably established by further experiment. In order to ascertain what effect the hydrochloric acid, formed during the decomposition, exerted upon the affinity of chlorine for hydrogen in presence of sun-light, pure chlorine-water and chlorine-water containing 10 per cent. of hydrochloric acid were insolated during the same period; the solution of pure chlorine lost 99·6 per cent.; whilst that containing 10 per cent. of hydrochloric acid lost only 1·3 per cent. of its contained free chlorine. The result of this and many other series of experiments*, justifies the conclusions,—

1. That the presence of hydrochloric acid retards in a remarkable degree the affinity of chlorine for hydrogen.

2. That owing to this retarding action, which is governed by entirely unknown laws, the examination of the photochemical decomposition of chlorine-water cannot lead to the discovery of any simple relations.

From these circumstances it appears probable that some simple law would be arrived at if the following conditions were complied with:—

1. That two elements which have no action upon each other in the dark, simply combine under the action of the light, so that the relative amounts of the uncombined bodies remain the same.

2. That the substance produced by the combination be either entirely removed from the sphere of chemical action, or be reduced to a small constant amount.

These two conditions are only found in the gas evolved by the electrolytic decomposition of hydrochloric acid. This gas consists, under certain conditions, of exactly equal volumes of chlorine and hydrogen, and is singularly well-fitted for a photometric substance. It is perfectly unalterable in the dark; it is not affected by lamp-

* See Quart. Journ. of Chemical Society, Oct. 1855.

or candle-light under the circumstances of the experiment, and is nevertheless so easily acted upon by solar light, that when perfectly free from all admixture, its component gases unite with explosion in the diffused light of a room.

In order to eliminate the source of error of the retarding action of the hydrochloric acid formed, it is only necessary that water saturated with the gaseous mixture should be present. By this means the hydrochloric acid is removed from the gas at the moment of its production, and thus a diminution of the volume of the gas is effected. This diminution of volume is a direct measure of the amount of chemical action of the light, and it is upon this fact that the method of measuring photochemical action rests. According to this method, and by carrying out a great number of necessary precautions, the following laws were arrived at:—

1. *The amount of chemical action is directly proportional to the time of insolation.*
2. *The amount of chemical action is directly proportional to the intensity of the light.*

The law connecting the amount of action with the mass of the decomposing body is not as yet completely established, but the results obtained seem to show that the light suffers mere optical absorption, and is not in any way expended, and therefore cannot be represented by any equivalent in chemical action.

Many very interesting phænomena connected with the action of solar light upon mixtures of chlorine and hydrogen will be fully treated of in the next communication to the Association.

In the prosecution of these researches the authors reserve to themselves the examination of all subjects arising out of this method; amongst others,—

1. The reflexion and absorption of the chemical rays.
2. Polarization of the chemical rays.
3. Examination of the arrangement of the chemical rays in the spectrum.
4. Application of the method to meteorological observation.

On the Manufacture of Iron by Purified Coke.
By F. Crace Calvert, *F.C.S.*

After pointing out what were believed to be the causes of the inferiority of iron in many works, apart from the varying qualities of the ores, the injurious action which an impure fuel had upon the quality of the iron was particularly alluded to; and the necessity of removing sulphur from the coal or coke, in the blast-furnaces, before it could be imparted to the cast iron during the process of smelting, was strongly enforced. Mr. Crace Calvert then referred to several instances in which the quality of iron, by the application of the chloride of sodium in the blast-furnace, had been greatly improved. These improvements were described to have been effected at a very small cost by the following simple process. If the blast-furnace was worked entirely with coal, chloride of sodium was added with each charge, in proportion to the quality of ore and flux employed; but a better result was produced if the coal was previously converted into coke, and a very slight excess of the chloride was used in its preparation in order to act on the sulphur of the coal and of the ore, should any be found therein; and a greater improvement was manifested in the quality of iron, when only coke so prepared was used in the blast-furnace. The coke so purified emitted no sulphurous fumes when taken out of the coke-oven; nor, when extinguished with water, did it give off the unpleasant odour of sulphuretted hydrogen; nor was any sulphurous acid gas liberated during the operation of smelting iron in the cupola, or in raising steam in the locomotive boiler, by coke so prepared; and it was stated that these decided advantages were gained, in some cases, at an additional cost of only one penny per ton of fue .

Mr. Crace Calvert gave the results of a series of experiments which had been made upon trial bars one inch square, cast from iron melted in the cupola, with coke prepared by his process. He exhibited specimens of the iron so prepared, when the closeness of texture and the absence of the 'honeycomb' appearance prevailing in the iron cast with ordinary coke were clearly demonstrated.

The mode of experimenting was described and the results were given very fully, and it was shown that the average increase of strength was from 10 to 20 per cent.

At the Works of	Mean breaking weight of Bars melted by		Difference in favour of Purified Coke.
	Ordinary Coke.	Purified Coke.	
Fairbairn and Sons, Manchester ...	427 lbs.	512 lbs.	20 per cent.
J. and W. Galloway and Co., do. ...	547 ...	620 ...	13 ... ...
Fox, Henderson and Co., Birmingham......................No. 3 iron.	455 ...	514 ...	18 ... ...
Ditto ditto 2 „	417 ...	459 ...	10 ... ...
Hibbert, Platt, and Co., Oldham ...	499 ...	552 ...	10 ... ...
Monkland	578 ...	641 ...	10 ... ...
Joicey and Co., Skinnerburn	616 ...	*741 ...	20 ... ...
Newcastle	658 ...	*716 ...	9 ... ...
Elswick Foundry	695 ...	*863 ...	24 ... ...

* Were bars 3 feet 10 inches and 4 feet only in length.

The following conclusions were arrived at by W. Fairbairn, Esq., F.R.S., by taking the mean of an extensive series of experiments:—The mean breaking-weight of the bars one inch square, smelted with the improved coke, was 515·5 lbs.; ditto, with ordinary coke, 427·0 lbs., equal to 88·5 lbs. in favour of the castings produced from the improved coke, or in ratio to 5 : 4. The experiments on the bars smelted with the improved coke, indicated iron of a high order of strength, and might be considered equal to the strongest cold-blast iron. The metal appeared to have run exceedingly close, and exhibited a compact granulated structure, with a light gray colour.

On Alloys. *By* F. C. CALVERT, *F.C.S.*, *and* RICHARD JOHNSON.

The authors have succeeded in producing many new alloys having a definite chemical equivalent composition, therefore bringing a large class of products called alloys into the general laws of definite proportion.

The following alloys of iron and potassium, viz.

First Alloy,

4 equivalents of iron,
1 equivalent of potassium,

Second Alloy,

6 equivalents of iron,
1 equivalent of potassium,

were prepared with the view of rendering iron less oxidizable when exposed to a damp atmosphere, no kind of coating having been discovered which will resist the constant friction of water,—as in the case with iron steamers. But all the alloys which they have produced up to the present time, with the exception of one, are oxidizable, although some of them contain as much as 25 per cent. of potassium, the most electro-positive metal known, and the one most likely to render iron in that electro-chemical state less liable to combine with oxygen. The above alloys of potassium and iron were remarkable for their great hardness.

The authors have also succeeded in producing two new alloys composed of iron combined with aluminium. These two alloys are composed as follows:—

First Alloy.

1 equivalent of aluminium,
5 equivalents of iron.

Second Alloy.

2 equivalents of aluminium,
3 equivalents of iron.

The last alloy presents the useful property of not oxidizing when exposed to a damp atmosphere, although it contains 75 per cent. of iron.

The authors hope to find, between this date and the next Meeting of the Association, a practical method of preparing this desirable alloy, which would render eminent service to manufacture.

The following alloys were also described, one composed of one equivalent of aluminium and five equivalents of copper; one other of iron and zinc composed of one equivalent of iron and twelve equivalents of zinc; and what is interesting respecting this last alloy, is not only its extreme hardness, but that it is produced at a temperature of about 800°, it being formed in a bath of zinc and tin containing 14 tons of metal, and through which iron-wire is passed when coated with zinc or galvanized.

The authors took advantage of having large melted mass of metals (zinc and tin) at their disposal, to inquire into the following question, viz. if two metals, when melted together, separate according to their respective specific gravity, or form a homogeneous mass combined in definite proportions.

They consequently analysed three samples taken from the melted bath, one near the top, one in the middle, and one at the bottom. Strange to say, they all presented a different composition; and what is not less remarkable is, that the upper layer contained the largest proportion of the heaviest metal. These three samples offered the following equivalents and definite composition:—

Top. { 1 equivalent of tin,
11 equivalents of zinc.

Middle { 1 equivalent of tin,
16 equivalents of zinc.

Bottom { 1 equivalent of tin,
19 equivalents of zinc.

The authors also prepared several alloys of zinc and copper; copper, zinc, and tin and copper, zinc, tin and lead, having definite and equivalent composition; but they intend to enter more fully into this subject next year.

The action of acids on these alloys of copper, zinc, &c. presents this curious fact, viz. that although hydrochloric acid attacks zinc and tin violently, still, in alloys containing these metals with copper, they are not, or very slightly attacked by this powerful acid. Similar results were also obtained with sulphuric and nitric acids.

On the Action of Sulphuretted Hydrogen on Salts of Zinc and Copper. By F. Crace Calvert, *F.C.S.*

In all our treatises of analytical chemistry, it is stated that the process to be followed to separate zinc or its compounds from those of copper, is to render the liquors acid which contain salts of these metals, and to pass a current of sulphuretted hydrogen, when the copper will be precipitated in the state of sulphuret, leaving the zinc in solution.

Having had lately to analyse several alloys of zinc and copper in connexion with some researches on alloys, the author found it impossible to make two analyses of the same alloy correspond satisfactorily. To ascertain the cause of error, he made several trials, and soon found out that zinc, even in very acid liquors, was freely and sometimes completely precipitated from them by sulphuretted hydrogen. He also remarked that the facility with which zinc was precipitated from an acid solution depended in a great measure on the peculiar salt of zinc which was in solution, and the nature of the acid employed to acidify the liquor. The results contained in this paper are so conclusive on this point, that the old method (which is still recommended in recently published works on quantitative analysis) for the separation of salts of zinc from those of copper must in future be rejected as completely inexact.

The experiments were made by employing 18 grains of crystallized and pure sulphate of zinc, dissolving them in 400 grains of distilled water, and adding to the liquor equivalent quantities of an acid; for example, as there existed in the quantity of sulphate of zinc used for the experiment (18 grains) 5 grains of sulphuric acid, 2·5, 5, 10, 12·5, or 15 grains of sulphuric acid were added, after being previously mixed with such a proportion of water as to give in each jar of an experiment 1500 grains

of fluid. The time required for a precipitate to appear was carefully noted down, and also the time which elapsed before the liquors were filtered off. The filtrates were then tested to ascertain if any salt of zinc remained in solution. The results obtained are given in the Tables.

TABLE I.

No.	$SO_3ZnO+7HO$.	Sulphuric acid.	Water. grs.*	Time when precipitate appeared.	Time of passing HS through liquor.	
1.	18 grs. (containing 5 grs. of SO^3) in 400 grs. water	2·5 grs. (half the quantity of SO^3 of the sulphate) in 50 grs. water	1050	The precipitate appeared in all cases in the space of from 3 to 10 minutes after the saturation of the liquor with HS. Rapidity of current has influence.	4 hours	Precipitation complete.
2.	18 grs. in 400 grs. water	59 grs. in 100 grs. water	1000		4 hours	
3.		7·5 grs. in 150 grs. water	950		4 hours	
4.		10 grs. in 200 grs. water	900		6 hours	A trace of zinc not precipitated.
5.		12·5 grs. in 250 grs. water	850		6 hours	The greatest part of the zinc precipitated.
6.		15 grs. in 300 grs. water (or 3 equivalents) ...	800		6 hours	

Mr. Calvert also made another series of experiments in which he employed weaker solutions, viz. diluting with twice their bulk of water similar solutions to those obtained in the above table, and these are the results obtained :—

TABLE II.

No.	$SO_3ZnO+7HO$.	Sulphuric acid.	Water. grs.†	Time when precipitate appeared.	Time of passing HS through liquor.	
4*a*.	18 grs. in 500 grs. water	10 grs. in 100 grs. water	3900	After a few minutes	5 hours	All precipitated.
5*a*.		12·5 grs. in 125 grs. water	3875	ditto	5 hours	Almost all precipitated; after 12 hours' standing, complete.
6*a*.		15 grs. in 150 grs. water	3850	ditto	5 hours	Precipitate not complete even after 12 hours' standing; the quantity not precip. was considerable.

It will be observed, in perusing the above tables, that zinc is freely and generally completely precipitated from its combination with sulphuric acid, even in liquors containing a great excess of sulphuric acid, or from 3 to 4 times as much free sulphuric acid as existed in the quantity of salt used.

Mr. Calvert also thought it advisable to make a series of experiments, employing chloride of zinc, and adding to it submultiple or multiple quantities of hydrochloric acid; and these were the results obtained.

The required amounts of acid were calculated by employing a quantity of acid containing a given proportion of chlorine.

* The quantity of water in column 3 is such, that when added to the quantity of water in columns 1 and 2, the sum is always 1500 grains.

† Total quantity employed, 4500 grains.

TABLE III.

No.	Chloride of zinc.	Hydrochloric acid.	Water. grs.	Time when precipitate appeared.	Time of passing HS through liquor.	
1.	10 grs. (containing 5·26 of chlorine, or 5·33 hydrochloric acid in 250 grs. water.	2·63 grs. (half the quantity of the chloride) in 125 grs. water	1125	3 minutes	5 hours	A considerable quantity of zinc precipitated, but not complete.
2.	10 grs. in 250 grs. water	5·26 grs. in 250 grs. water	1000	5 minutes	5 hours	Only partially precipitated.
3.		7·89 grs. in 375 grs. water	875	8 minutes	5 hours	Small quantity precipitated.
4.		1·32 grs. in 250 grs. water	1000	3 minutes	5 hours	Precipitate not complete.
5.		0·66 grs. in 125 grs. water	1125	3 minutes	5 hours	Almost all precipitated.
6.		0·33 grs. in 62 grs. water	1188	2 minutes	5 hours	A trace not precipitated.
7.		0·165 grs. in 250 grs. water	1150	2 minutes	5 hours	All precipitated.
		Influence of Dilution with Water.				
4*a*.	10 grs. in 110 grs. water	1·32 grs. in 250 grs. water	4140	3 minutes	5 hours	Precipitate complete without leaving it to stand for a longer time.
4*aa*.		1·32 grs. in 250 grs. water	7140	3 minutes	5 hours	Precipitate complete.

In comparing the results contained in this Table with those of the previous ones, it will be noticed that zinc is more easily precipitated from its combination with chlorine, and in presence of an excess of hydrochloric acid, than when it is combined with sulphuric acid. Still, in either case, and even in presence of a very large excess of acid, zinc is precipitated, and in many cases completely.

Before undertaking a series of experiments to discover a new method of separating quantitatively zinc and copper, the author thought it advisable to examine the various processes which have been proposed of late years, and these are the results:—

He first made a series of experiments with a process which has been recommended by Messrs. Rivot and Bouquet, and which consists in adding an excess of ammonia to an acid liquor containing the above two metals, and then adding caustic potash in slight excess. The liquor is to be heated to 158° Fahr. until the whole of the ammonia is expelled, the copper being thrown down in the state of black oxide, whilst the oxide of zinc remains in solution; but Mr. Calvert has always found, even in employing diluted liquors and a very slight excess of potash, that a certain proportion of hydrate of oxide of zinc, dissolved in the caustic potash, was dehydrated, became insoluble, and precipitated with the oxide of copper, thereby increasing its relative proportion, and rendering the results incorrect.

The two methods having failed in his hands, although he had taken all the necessary precautions recommended to carry out those processes successively, he next had recourse to the methods proposed by M. Flajolot. The first consists in adding to a boiling solution of zinc and copper, rendered slightly acid by sulphuric acid, hyposulphite of soda, until no more black protosulphuret of copper precipitates, filtering, and determining the copper by oxidizing the sulphuret with nitric acid in the usual way, and throwing down the copper. The zinc is precipitated with carbonate of soda. The second process given by this chemist consists in estimating the copper by precipitating it in the state of protoiodide by a solution of iodine in sulphurous acid*.

Both these processes of M. Flajolot gave very satisfactory results, and can be adopted when a complete analysis of an alloy of zinc and copper is required; but as these methods require too much time when rapid analyses are desired, the author next tried M. Pelouze's method, which consists in rendering the liquor containing salts of zinc and copper alkaline with an excess of ammonia, and pouring very gradually into it a standard solution of monosulphuret of sodium, which first precipitates all the copper as black sulphuret, leaving the zinc in solution. As this latter metal yields a white sulphuret, it is easy to ascertain when all the copper is precipitated. This method is

* For further details see 'Chemist,' vol. i. p. 411.

so easily and rapidly performed, that he thought it advisable to test its accuracy, and the following results leave no doubt as to its exactitude and value. The zinc is determined by difference.

		Taken.	Obtained.
I.	Copper	1·16	1·17
	Zinc	17·97	17·96
II.	Copper	9·91	9·935
	Zinc	3·55	3·525

Description of Dr. CLARK's *Patent Process for softening Water, now in use at the Works of the Plumstead, Woolwich, and Charlton Consumers' Pure Water Company, together with some Account of their Works. By* D. CAMPBELL, *F.C.S.*

According to the author, the process of Dr. Clark for softening water may be applied with advantage to water from the chalk strata, water from the New Red Sandstone, and waters which contain carbonate of lime in solution from any strata. It is briefly described as follows; namely, by adding a quantity of milk of lime to the water, it takes carbonic acid holding carbonate of lime in solution; and forms a precipitate of carbonate of lime, throwing down at the same time the quantity of carbonate of lime held in solution by the carbonic acid, and thus rendering the water soft. The works and operations for carrying out the process were fully described by diagrams. One peculiar feature in the water after it had been softened, and which was not anticipated by Dr. Clark when he first took out his patent, is, that it does not show the slightest sign of vegetation, though exposed to the sun and light for upwards of a month, whilst the water before softening cannot be kept above a few days without producing Confervæ; and if this be not immediately removed, decay commences quickly, and small insects are soon observed, which feed upon the decaying vegetable matter; and the water soon assumes a bad taste. This is continually the case when the water is kept in large reservoirs, and its removal occasions considerable trouble and expense. The author had endeavoured to explain the reason of this marked difference between the unsoftened and the softened water; and he was nearly satisfied that the vegetating principle in the water was more especially due to the carbonic acid holding the carbonate of lime in solution than to the volatile matter, or, as it is sometimes called, organic matter. The process is applicable to many towns already supplied with water from the chalk and from the New Red Sandstone, and if properly applied will be found to pay the expense of its working, and confer a great boon upon the populations, the enlightenment of whose corporations may induce them to adopt it.

On the Preservation of the Potato Crops. By Chevalier DE CLAUSSEN.

At the meeting of the British Association in Hull, two years ago, the author proposed sulphate of lime as a means of preserving the potato. He has since, by successive experiments, convinced himself that it is entirely efficient. He wets them with water acidulated with sulphuric acid (1 part acid, 500 parts water), and before they are dry throws over them powdered sulphate of lime, or plaster of Paris, by which process they are covered with a thin film of sulphate of lime. If the potatoes are already attacked partially with the disease, they must be left from six to twelve hours in the acidulated water before the sulphate of lime is used; but in case they are free of disease, a few minutes are sufficient. It is very possible that sulphate of lime, with an excess of sulphuric acid added to the soil in which potatoes grow, may be useful; but he has not made any experiment to this purpose. He has ground to suppose that chemical combinations in contact with animal or vegetable products have a tendency to preserve them, in the same way as the combination of oxygen and zinc preserves iron, and that this is one of the causes why the combination of water with the sulphate of lime preserves potatoes and other vegetables; and that in the same time the small quantity of free sulphuric acid destroys the fungus which causes the disease.

On the apparent Mechanical Action accompanying Electrical Transfer. By Mrs. Crosse.

Dr. Playfair stated, that at the last meeting of the Association, Mr. Crosse, who is recently dead, had read a communication on some phænomena which took place in the electric current, and it was objected on that occasion, that it was possible the gold which was carried over might have been impure gold; and that it was owing to a solution of copper that was in the gold that these mechanical phænomena ensued. Mrs. Crosse, with a desire to show the accuracy of her husband's experiments, had since his death repeated the experiment with pure gold, and obtained the results mentioned in the communication.

Extracts from a Letter from the Rev. A. S. Farrar, *of Queen's College, Oxford, on the late Eruption of Vesuvius (read by* Dr. Daubeny).

The writer sketched the recent history of the volcano down to the late eruption. A new crater was formed in December 1854 by the sudden giving way of a portion of the summit of the great cone, which, however, revealed little of the internal structure of the mountain, though it discharged only gas. The eruption commenced on May 1st, 1855, from ten craters which broke out in one long line down the north side of the cone. The lava continued to flow for twenty-eight days, and destroyed much valuable property, passing down the ravines between the Monte Somma and the Observatory, and pursuing its course in the plain to a distance of six miles. Professor Palmieri has taken meteorological observations at the Observatory near the Hermitage. The magnets were affected for two days previously to the outburst of the lava, with remarkable oscillations analogous to those observed in 1851, during the earthquake at Melfi. The development of electricity was strongly marked, of a nature always positive, and yielding different results when studied with a fixed conductor, and the same made moveable according to Peltier's method. The Neapolitan Professors Scacchi and Palmieri intend to publish their observations. Mr. Farrar concluded with an account of M. Deville's Chemical Observations on the gases emitted by the fumaroles, as recorded in the 'Comptes Rendus' for June and July, 1855.

On an Indirect Method of ascertaining the presence of Phosphoric Acid in Rocks, where the quantity of that ingredient was too minute to be determinable by direct analysis. By Professor Daubeny, *M.D., F.R.S.*

The method employed was to sow on a portion of the rock, well-pulverized, and brought into a condition, mechanically speaking, suitable to the growth of a plant, a certain number of seeds in which the amount of phosphoric acid had been determined by a previous analysis.

It is evident, that whatever excess of phosphoric acid over that existent in the seed was detected in the crop resulting, must be referred to the soil in which the plant had grown, and hence would serve to indicate the existence of that quantity at least in the rock.

Now when chalk, oolite, magnesian limestone, red sandstone, and other rocks in which organic remains are usually present, were made the subject of experiment, the existence of phosphoric acid in the rock was always detected by the foregoing method, the phosphoric acid in the crop exceeding the amount of that in the seeds sown.

But when the slates that lie at the bottom of the Silurian system, such as those of Bangor and Llanberris in North Wales, were tested in the same manner, the almost entire absence of phosphoric acid in them was inferred from the scantiness of the crop, which in each instance contained scarcely more of phosphoric acid than had been present in the seeds from which it had been derived. Nor was this owing to any mechanical impediment to their growth; for when the rock was manured with phosphate of lime, a crop was obtained from it as large as in the preceding cases.

These experiments tend therefore to show that the rocks above named really were

deposited where no living beings existed; for although the absence of organic remains in them might be accounted for by metamorphic action, the heat which obliterated the latter would exert no influence upon the phosphoric acid which all animals and vegetables contain, and which therefore would still remain in a rock made up in part of their exuviæ, even if it had undergone fusion.

Dr. Daubeny suggested that this method of investigation might throw some light upon the much-disputed question, whether any rocks are known which were antecedent to the commencement of organic life; and also, in a practical point of view, might be useful by showing, whether manuring with phosphate of lime was likely to be serviceable in increasing their agricultural value.

The second subject adverted to in this communication related to the reputed existence of phosphoric acid in certain rocks of Connemara in Ireland, which Sir Roderick Murchison had referred to the Silurian epoch.

These limestones, although totally destitute of organic remains, and possessing all the characters of primitive limestone, being crystalline and interstratified with quartz rock and mica slate, often contain, according to a recent analysis, a large per-centage of phosphoric acid; and this statement, Dr. Daubeny, from a hasty examination which he had made of them upon the spot, was disposed to credit, so far at least as relates to the presence of traces of this ingredient in the limestones referred to*.

Should this fact be substantiated by further investigations, it will not only confirm Sir R. Murchison's previous opinion as to the age of these limestones, but will also show that they are likely to be of value as manures, by reason of the phosphoric acid which they contain.

On the Action of Light on the Germination of Seeds. By Professor DAUBENY, *M.D., F.R.S.*

An opinion has gone abroad, and has found a place in several standard treatises†, that as the luminous rays favour the development of the growing plant, so the chemical rays promote the germination of the seed.

The authority upon which this statement rests, seems to be that of some experiments instituted by Professor Robert Hunt, who, whilst employed in investigating the chemical action of light upon inorganic bodies, and its application to photography, turned his attention likewise to the influence of the same agent upon plants.

One circumstance alone, however, might raise a doubt as to any direct effect having, in the instances reported, been produced by the several solar rays, namely that, so far as can be collected from the statement given, all the seeds tried by Mr. Hunt were buried in the ground to the usual depth. Now I found that a depth of two inches of common garden soil was quite sufficient to intercept the rays of light, so as to prevent the slightest chemical action being exerted upon highly sensitive paper placed beneath it.

The improbability, therefore, of a ray of light acting through such a medium induced me to institute a set of experiments, in which the seeds were placed on the surface of moist earth exposed to the action of particular portions only of the solar spectrum.

Although the results obtained are rather of a negative than of a positive description, and have likewise been in some measure superseded by the researches already published by Dr. Gladstone, yet as the experiments have been repeated during the last summer, and lead uniformly to similar results, they are communicated, as justifying the conclusion to which I had arrived, that no positive influence of a direct kind in promoting germination can be traced to the chemical rays of light, when compared with other portions of the sunbeam.

Six sorts of seeds were in general employed in these experiments, and the number of radicles and plumules of the several kinds which had protruded each day were duly registered.

The media employed for isolating certain rays, or at least particular portions

* These limestones have been since examined more carefully by Dr. Daubeny, and the quantity of phosphoric acid present in them found to be much smaller than that reported in the analysis referred to. See Proceedings of the Ashmolean Society for Oct. 29, 1855.

† See in particular Mrs. Somerville's work on Physical Geography.

of the spectrum, are enumerated in the table annexed, by reference to which it will be at once seen, what specific luminous influence was exerted upon the seeds by each of those coloured glasses or fluids which are named in the brief statement of the experiments which follow.

I am indebted to Mr. Maskelyne, the Deputy-Reader of Mineralogy at Oxford, for having examined the various media employed, and defined by reference to Frauenhofer's lines the exact quality of the rays transmitted by each, as is stated in the Table. (See Plate VI.)

In the first set of experiments a south aspect was selected, and the following seeds were experimented upon, viz.—

Datura Catula	10	Helianthus annuus	13
Malope grandiflora	14	Polygonum fagopyrum........	16
Trifolium incarnatum	14	Hordeum sativum............	14
Raphanus rotundus	12	In all	93

But as none of the two first came up, the real number operated upon may be estimated at 69. Of these—

46 radicles and 18 plumules came up under violet light.
44 radicles and 18 plumules came up under green glass.
41 radicles and 19 plumules came up in one instance } in darkness.
41 radicles and 5 plumules came up in another instance }
36 radicles and 26 plumules came up under cobalt-blue glass.
32 radicles and 17 plumules came up under amber glass.
29 radicles and 7 plumules came up under ruby glass.
23 radicles and 5 plumules came up under orange glass.

Accordingly, in this series a slight superiority seemed certainly to belong to the violet-coloured medium over the rest, in relation to the number both of radicles and of plumules which appeared; whilst in respect to the quickness of their germination, the violet and green media were a-head of the rest, although the plumules did not follow the same order.

When, however, the same experiments were repeated in a north aspect, the same law did not hold good, for out of 69 seeds,—

52 radicles and 22 plumules appeared under green glass.
49 radicles and 17 plumules appeared under blue glass.
47 radicles and 14 plumules } appeared in darkness.
47 radicles and 21 plumules }
44 radicles and 17 plumules appeared under transparent glass.
39 radicles and 23 plumules appeared under violet light.

And with respect to the quickness of germination, it appeared that the green stood first in order; that the seeds under blue and violet glass and in absolute darkness came up next in order, and with nearly equal rapidity; that those in full light were next in order; whilst orange, ruby, and yellow were about equal, but somewhat later than the rest.

It did not appear, therefore, from this last series of experiments, that violet light favoured germination at all more than any other species of light; nor indeed that any kind of ray was injurious to the process, so long as its intensity was not too great, as may be inferred to have been the case in the first set of experiments, where the seeds were exposed to the full rays of the sun in a southern aspect.

I therefore, in my subsequent experiments, selected uniformly a north aspect for the germination of the seeds; and in order still further to test the point as to whether the quality of the light had anything to do with the process, I placed as before upon the surface of the soil, in boxes, ten seeds of each of the four following plants, viz. peas, beans, kidney-beans, and a species of sunflower (*Helianthus annuus*), all of which germinated. Now in this case

37 radicles and 25 plumules appeared in the dark box;
36 radicles and 30 plumules appeared under green glass;
35 radicles and 30 plumules appeared under blue glass;
34 radicles and 24 plumules appeared under transparent glass;

the whole number of seeds operated upon being only 40.

It would seem, then, as if in these cases the absence or presence of light was almost a matter of indifference.

In the fourth series of experiments rather a greater variety of species was experimented upon, and a larger number of media employed, the total number of seeds in each box being 52, viz. of a species of sunflower, peas, kidney-beans, and barley, 10 of each, and of radishes 12. In this instance, the whole number came up under four of the media employed, but these media were of very different qualities; in one case, all light being excluded; in another, the violet ray alone admitted; in another, green light; and in the fourth, a pale green glass being used, which cut off none of the rays completely, although it enfeebled all.

The number of plumules that were developed in these several instances, were from 46 to 47.

The number of radicles developed under transparent glass was only less by two than the others, so that no fair inference would seem deducible from this series, in favour of one medium being preferable to another. The radicles, however, came up most rapidly in total darkness, and least so when all the rays were admitted.

Although the above four sets of experiments seemed to render it improbable that any influence, favourable or otherwise, could be traced to particular rays or portions of the spectrum, still it seemed desirable to show more directly, that where the quantity of light was the same its quality was immaterial.

It was with this view principally that I instituted a fifth set of experiments, in which the light was filtered as it were through liquids—one of which was the ammonio-sulphate of copper, which excluded all but the violet; another, port wine, which admitted only the extreme red; and a third, a mixture of ink and water, which deadened equally all the rays of the spectrum.

It was in the first place ascertained, as nearly as could be done by the eye, that an equal amount of light was admitted through each of the media, they being severally diluted with water, until they allowed just so much light to pass as was sufficient for reading the largest print in a chamber otherwise darkened.

The results appear to show, that there was under these circumstances scarcely any difference to be detected; nor indeed did a glass, which admitted allthe light present, appear to interfere with the process materially, although in the box from whence light was entirely excluded the germination seemed to go on somewhat less vigorously than in the others.

It will be seen at least, that out of 50 seeds, or 10 of each of the following, radishes, peas, kidney-beans, sunflower, and barley,

49 radicles and 48 plumules appeared under port wine.
49 radicles and 43 plumules appeared under ink and water.
47 radicles and 36 plumules appeared under transparent glass.
46 radicles and 48 plumules appeared under $\left.\begin{matrix} \\ \\ \end{matrix}\right\}$ ammonio-sulphate of copper.
45 radicles and 98 plumules appeared under
42 radicles and 37 plumules appeared in total darkness.

Upon the whole, from a general survey of the above experiments, no other conclusion seems deducible, except that light has very little to do directly with the germination of seeds; and that although the popular opinion may be well-founded, namely, that the process goes on best in the dark, as maltsters generally believe, still that the light which interferes with the success of the operation acts chiefly by producing such a degree of dryness as is unfavourable to the sprouting of the seed, and not by itself interfering directly with the result.

An experienced maltster, indeed, assures me, that darkness is not necessary for malting, although, in order to maintain a suitable degree of humidity in the apartment, strong light is generally excluded.

In the Tables annexed, the numbers attached to each column indicate merely the relative number of radicles or plumules, which had been found to develope themselves under the several media employed, on each of the days of which the date is given.

First set of Experiments.—In a South Aspect.—SUMMARY.

Numbers that had vegetated on each day.—Experiment beginning April 13.

Media.	April										
	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	
No. 1. White	0	0	1	3	5	8	11	15	19	...	P
	0	2	6	10	14	18	22	26	30	...	R
No. 2. Blue	0	0	2	5	8	12	16	21	26	...	P
	2	6	10	14	18	22	26	32	36	...	R
No. 6. Amber ...	0	0	0	2	4	6	10	14	18	...	P
	1	4	7	10	13	17	22	27	32	...	R
No. 5. Ruby......	0	0	0	0	0	0	2	4	7	...	P
	0	2	5	8	11	14	19	24	29	...	R
No. 7. Orange ...	0	0	0	0	0	1	2	3	5	...	P
	0	2	4	6	8	10	14	18	23	...	R
No. 3. Green ...	0	0	0	2	4	6	10	14	18	...	P
	4	9	14	19	24	29	34	39	44	...	R
No. 11ª. Black ...	0	0	0	2	4	7	11	15	19	...	P
	3	7	11	15	19	24	29	35	41	...	R
No. 11ᵇ. Black	0	0	0	0	0	0	1	3	5	...	P
	2	6	11	16	21	26	31	36	41	...	R
No. 8. Violet	0	0	0	3	6	9	12	15	18	...	P
	4	9	14	19	24	29	34	40	46	...	R

Second set of Experiments.—In a North Aspect.—SUMMARY.

Numbers that had vegetated on each day.—Experiment beginning April 28.

Media.	May										
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	
No. 1. White	...	...	...	1	...	11	...	17	...	...	P
	11	31	38	41	...	43	...	44	...	...	R
No. 2. Blue	...	...	...	...	...	14	...	24	...	...	P
	18	36	43	46	...	48	...	49	...	...	R
No 7. Orange	...	...	...	...	...	8	...	17	...	...	P
	8	28	33	37	...	37	...	41	...	...	R
No. 5. Ruby	...	...	...	...	...	5	...	14	...	...	P
	8	31	36	38	...	40	...	44	...	...	R
No. 6. Amber	...	...	...	...	...	6	...	8	...	...	P
	8	29	38	41	...	42	...	43	...	...	R
No. 3. Green	...	...	...	...	...	5	...	22	...	...	P
	23	37	49	51	...	52	...	52	...	...	R
No. 11ª. Black	...	...	...	2	...	3	...	14	...	...	P
	5	28	36	41	...	43	...	47	...	...	R
No. 11ᵇ. Black	...	...	...	...	...	10	...	21	...	...	P
	15	32	42	45	...	45	...	47	...	...	R
No. 8. Violet	...	...	...	...	...	19	...	23	...	...	P
	16	31	36	37	...	38	...	39	...	...	R

Third set of Experiments.—In a North Aspect.—SUMMARY.

Numbers that had vegetated on each day.—Experiment beginning May 16.

Media.	June													
	3.	4.	5.	6.	7.	8.	9.	11.	13.	15.	17.	21.	23.	
No. 1. White......	...	...	...	...	5	7	7	9	15	21	23	24	24	P
	8	19	19	23	31	33	33	34	34	34	34	34	34	R
No. 2. Blue	...	...	...	...	9	9	10	15	20	24	25	30	30	P
	9	20	20	30	33	35	35	35	35	35	35	35	35	R
No. 3. Dark Green	...	...	...	...	5	10	10	14	20	25	27	30	30	P
	9	20	20	29	33	35	36	36	36	36	36	36	36	R
No. 4. Black	...	...	...	...	5	10	12	13	21	23	25	25	25	P
	18	18	18	25	33	33	33	36	36	37	37	37	37	R

Fourth set of Experiments.—In a North Aspect.—SUMMARY.

Numbers that had vegetated on each day.—Experiment beginning July 28.

Media.	August																		
	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	
No. 1. White	...	1	9	16	16	25	25	27	30	35	36	36	37	37	41	41	41	46	P
	20	40	42	42	42	44	44	45	46	46	46	46	46	46	49	49	49	50	R
No. 4. Light Green...	...	...	13	27	27	29	29	30	34	34	37	37	37	37	42	42	42	44	P
	21	38	40	40	40	44	44	45	45	45	45	45	45	45	52	52	52	52	R
No. 3. Dark Green...	...	...	17	20	20	27	27	28	33	35	37	38	40	42	47	47	47	47	P
	23	46	46	47	47	48	48	48	50	50	50	50	50	50	50	50	50	52	R
No. 2. Blue..	...	5	16	26	26	27	27	27	32	36	38	38	38	38	46	46	46	46	P
	25	41	43	43	43	43	43	43	43	43	43	43	43	43	48	46	46	46	R
No. 8. Violet	...	...	23	30	30	30	30	40	42	43	43	43	43	43	46	46	46	46	P
	23	42	45	45	45	45	45	45	46	46	46	46	46	46	52	52	52	52	R
No. 11. Black	...	1	10	20	20	22	22	22	27	30	37	37	38	38	47	47	47	47	P
	31	43	45	45	45	47	47	47	48	48	48	48	48	48	52	52	52	52	R

Fifth set of Experiments.—In a North Aspect.—SUMMARY.

Numbers that had vegetated on each day.—Experiment beginning May 25.

Media.	June																	
	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	17.	19.	20.	21.	23.	26.	
No. 1. White ..	...	...	...	3	3	3	10	15	20	26	26	32	32	34	34	35	36	P
	20	26	34	37	37	37	41	41	46	46	46	47	47	47	47	47	47	R
No. 11. Black..	...	...	3	3	7	13	17	20	20	25	25	29	31	32	32	33	37	P
	...	37	40	40	41	41	41	41	42	42	42	42	42	42	42	42	42	R
No. 8ª. Sulphate of Copper..	...	...	...	...	1	2	7	8	11	20	20	28	31	34	34	34	38	P
	...	22	33	33	33	34	36	37	38	44	44	44	44	44	44	44	45	R
No. 9. Port Wine	...	3	3	7	10	24	27	28	31	35	35	37	37	40	40	42	48	P
	6	36	38	38	40	43	43	43	46	47	47	47	47	47	47	47	49	R
No. 8ᵇ. Sulphate of Copper..	...	...	3	3	5	11	18	23	26	33	33	35	36	39	39	40	45	P
	...	32	39	39	39	39	39	41	45	45	45	45	45	45	45	45	46	R
No. 10. Ink	...	...	...	...	...	2	8	12	18	26	26	33	35	38	38	39	43	P
	...	25	29	29	34	38	40	43	48	49	49	49	49	49	49	49	49	R

On the Titaniferous Iron of the Mersey Shore. By J. B. Edwards, *Ph.D., F.C.S., Lecturer on Chemistry at the Royal Infirmary School of Medicine, and Royal Institution, Liverpool.*

The sand along the western shore of the Mersey, especially between Seacombe and New Brighton, has long been observed to contain a considerable quantity of titaniferous iron, which is strongly attracted by the magnet, and thus readily separated from the shore sand. It occurs from the disintegration of boulders of granitic rock, which are found in a clay bed which rises abruptly from the shore to the height of about 30 or 40 feet, and is of limited extent. The formation of the district is new red sandstone, and this drift must have come from a considerable distance, and is generally ascribed to the hills of the Solway. Some of the masses of rock are very large, but the majority are of a few pounds' weight, or less. They are found in various stages of decomposition; some appearing quite hard, and speckled black, others green and crumbling, others in complete disintegration within the clay, and in this state the green colour is generally very marked. This is probably due to adhering oxide of iron undergoing change by the action of the atmosphere. When collected from among the sand of the shore, the crystals of the mineral appear of a uniform black colour.

The specimens examined were carefully separated from the shore sand by a magnet. Prof. Thomson's formula for iserine is FeO, TiO_2, and the analysis he gives is

TiO_2	50·12
FeO	49·88
	100·00

The spec. grav. he gives as 4·5, and states that it is strongly attracted by the magnet.

Gmelin gives the formula of $2FeO + TiO_2 =$

TiO_2	36·36
FeO	63·63
	99·99

These compounds may also be represented as oxides in which both metals are basic. Titanium being isomorphous with iron, the first compound therefore represents sesquioxide of iron, in which iron is partly replaced by titanium, and the latter magnetic oxide, with a similar substitution; thus

$$\left.\begin{matrix}Fe\\Ti\end{matrix}\right\}O_3 \text{ .... No. 1.}$$

$$\left.\begin{matrix}Fe\\Ti\end{matrix}\right\}O_4 \text{ .... No. 2.}$$

Many compounds of titaniferous iron have been examined, and the composition appears to vary very considerably. That which I now describe has a specific gravity of 4·82, and is powerfully attracted by the magnet; some of the particles also themselves attract iron. The results of three experiments gave as its composition the following:—

	Experiment.	Theory of formula.
TiO_2	13·20	13·74
FeO	31·10	30·92
Fe_2O_3	42·08	40·89
Al_2O_3	8·62	8·91
SiO_3	4·02	5·01
	99·02	99·47

This nearly agrees with the following formula:

$$2(FeO, TiO_2)\,3(Fe_3O_4) + Al_2O_3 + SiO_3.$$

If the iron exists, as here represented, in the state of magnetic oxide, the magnetic properties of the crystals would be thus explained.

On the Action of Sulphurets on Metallic Silicates at high Temperatures. *By* David Forbes, *F.G.S.*

This communication first treated of the sulphurets of metals formed by fusion, showing that very distinct compounds were thus formed generally more basic than under other circumstances. The action of sulphurets on silicates was illustrated by a series of researches, which showed that when the silicate of a weaker metal was fused along with the sulphuret of a stronger one, or *vice versâ*, the result was the same,—not a perfect mutual decomposition, as would have been expected, but the production of a double sulphur-salt of both metals. When the fusion, however, took place at lower temperatures, no action was found to take place. A series of specimens illustrated the occurrence of such reactions, metallurgical operations, and their chemical composition, &c.

On some Organic Compounds containing Metals. *By* Professor Frankland, *Ph.D., F.R.S.*

The author has continued his researches on the above-named compounds, and in a communication just presented to the Royal Society, has completed the history of zincethyl, which is produced by the action of zinc upon iodide of ethyl in close vessels, at a temperature of about 130° C. Zincethyl is a colourless, transparent, and mobile liquid, refracting light strongly and possessing a peculiar ethereal odour. Its specific gravity is 1·182. It boils at 118° C., and distils unchanged in an atmosphere of carbonic acid. The specific gravity of its vapour is 4·259. It therefore consists of two volumes of ethyl and one volume of zinc vapour, the three volumes being condensed to two.

Zincethyl inflames spontaneously in atmospheric air or in oxygen, burning with a brilliant blue flame fringed with green. When more gradually oxidized, it yields ethylate of zinc ($ZnO\,C_4\,H_5\,O$); with iodine it gives iodide of ethyl and iodide of zinc, and with bromium, chlorine, and sulphur the reaction is similar. Zincethyl decomposes water with almost explosive violence, forming oxide of zinc and hydride of ethyl.

These remarkable reactions lead the author to anticipate, that zincethyl will prove in the hands of chemists a new and valuable means of research; for it is evident from its reactions that it will be capable of replacing electro-negative elements in organic or inorganic compounds by ethyl; a kind of replacement which has never yet been attempted, but which the author anticipates will enable him to build up organic compounds from inorganic ones, and ascend the homologous series of organic bodies; by replacing, for instance, the hydrogen in a methylic compound by chlorine or iodine, and then acting upon this product of substitution by zincethyl or zincmethyl, the author believes that compounds higher in the series will be obtained, since he regards the higher homologues of methyl and its compounds as derived from the latter radical by the successive replacement of hydrogen by methyl.

The author, who is now engaged with researches in this direction, mentioned some substitution products derived from nitric acid in proof of the strong probability of the foregoing considerations.

On a Mode of conserving the Alkaline Sulphates contained in Alums. *By* Professor Frankland, *Ph.D., F.R.S.*

The ultimate object of the manufacture of alums is the production of a *pure* salt of alumina, and the alkaline sulphates contained in alums are employed only for producing with sulphate of alumina a readily crystallizable salt, which can be freed from impurities, and especially from oxide of iron, by repeated crystallizations. In almost every case in which alum is employed in the arts, the alkaline sulphate which it contains is utterly useless; it is consequently wasted and thrown away. The author therefore proposes to extract the alkaline sulphates from alums, thus producing pure sulphate of alumina, and conserving the alkaline sulphates, which latter can then either be sold as such, or employed for the preparation of a new quantity of alum. This

separation the author effects by dissolving the alum (ammonia alum is to be preferred) in hot water and then passing into the solution a stream of ammoniacal gas, produced by boiling the ammoniacal liquor of gas-works with lime, until the whole of the alumina is precipitated as a subsulphate; this precipitate is then to be separated from the solution of sulphate of alumina by means of canvas filters, or a hydro-extractor. The subsulphate of alumina, being then dissolved in sulphuric acid and evaporated, yields pure sulphate of alumina admirably adapted for the production of the usual alumina mordants of the calico-printer, and the filtered solution yields on evaporation crystallized sulphate of ammonia, about 9 cwt. of which will be produced from each ton of alum, one third, or 3 cwt., being separated from the alum itself.

On the Extraction of Metals from the Ore of Platinum. *By* Professor E. Frémy, *Paris.*

M. Frémy treated of the preparation of osmium, rhodium and iridium from the residues of the platinum ores. The preparation of osmium according to the old method is attended with great difficulties and actual danger. M. Frémy proposed to prepare osmium by passing atmospheric air over the residual ore, heated in a porcelain tube. The volatile osmic acid is condensed in glass balloons, and the less volatile oxide of ruthenium is found at the extremity of the heated tube. The rhodium remaining in the residual mass is separated from the other metal contained by chlorine gas at a high temperature.

On a New Glucocide contained in the Petals of a Wallflower. *By* J. Galletley.

On the Use of Phosphate of Potash in a Salt Meat Dietary. *By* Robert Galloway, *F.C.S.*

We know from the researches of Liebig that salted meat is less nutritious than unsalted meat, if the salting has been carried to such an extent as to produce brine; for the salt remains along with the water of the flesh, the different substances dissolved in it being albumen, lactic acid, kreatine, kreatinine and some of the mineral ingredients, especially phosphoric acid and potash. It is, in my opinion, the loss of the two latter substances which renders salted meat so unnutritious, because the fibrine of the flesh can supply the place of the organic substances, but none of the substances remaining in the flesh can supply the place of the phosphoric acid and potash, and even vegetables do not contain these substances in sufficient quantity to make up for the loss. To supply the deficiency, I propose that phosphate of potash be used with salted meat as common salt is with flesh; this addition would render salted meat nearly, if not quite, as nutritious as flesh, and as a consequence the diseases arising from the use of salted meat would cease.

On the Quality of Food of Artizans in an artificially heated Atmosphere. *By* Robert Galloway, *F.C.S.*

Some time ago I had to superintend the operations in a sugar refinery; during the time my attention became directed to the quality of the food consumed by the workmen. The temperature of a refinery varies from 90° to 120° Fahr., and the work is laborious. The workmen, as theory would predict, live almost exclusively upon nitrogenous substances; their food consists of bread and meat; and this is the more striking, as the men in their own country (the men employed in refineries are Germans), and at other occupations, live almost exclusively upon vegetables.

On a Crystalline Deposit of Gypsum in the Reservoir of the Highgate Waterworks. *By* J. H. Gladstone, *Ph.D., F.R.S.*

Dr. Gladstone laid on the table a large branching crystal of gypsum, weighing about half a pound. It was described as a small portion of a deposit which was found recently on cleaning out one of the reservoirs at Highgate. The clerk of the

works called it "congealed water," and supposed that it could not possibly have been brought there originally and placed in the position where it was found. The crystals had spread themselves over a stratum of clay, and had probably been formed by the action of slowly decomposing sulphurets on the carbonate of lime in the water or earth.

Experiments on the Compounds of Tin with Arsenic. By Ed. Haeffely.

These experiments had led to this practical fact, that the danger of using any arseniates in stannates of soda might be obviated by the use of pure stannate of soda alone.

On a new Form of Cyanic Acid. By the Baron Von Liebig, *Munich.*

In the course of some experiments on the fulminate of mercury, I observed that that compound, when kept boiling in water, changed its colour, and lost its fulminating properties. On examining the change that had taken place in the composition of the fulminate, I discovered a new acid, which had exactly the composition of cyanuric acid, but which differed entirely from that acid in its properties, and in the properties of the salts which are produced with the alkaline bases—salts remarkable for their beauty and for the distinctness of their crystalline form. Taking for the equivalent of hydrated fulminic acid the formula C2, NO, HO, the new acid is produced in a very similar manner. The elements of three equivalents of fulminic acid unite to form one equivalent of the new acid, to which I shall give the name of fulminuric acid. This acid is monobasic. Its salt of silver is soluble in hot water, and crystallizes from it in long, silky, white needles. The alkaline salts of the new acid are very easily prepared by boiling the fulminate of mercury with an alkaline chloride. The fulminate of mercury is first dissolved; then gradually two-thirds of the oxide of mercury precipitates, and the alkaline fulminate, with a certain quantity of chloride of mercury and potassium, remains in the solution. By employing the chloride of sodium, or the chloride of barium, we obtain, of course, a salt of the new acid, with a base of soda or of barytes. With chloride of ammonium an ammoniacal salt is obtained, the crystals of which are distinguished from all others by their adamantine brilliancy, and their high degree of power and lustre. These crystals belong to the Klinorhombic system, and possess double refraction almost as strongly as Iceland spar. The hydrated acid is easily obtained by decomposing the basic lead salt by means of sulphuretted hydrogen. It has a strongly acid reaction, and when reduced by evaporation to a state of syrup, it is transformed by degrees into a crystalline mass, which dissolves in alcohol, and which, by the action of acids, is changed into carbonic acid and ammonia.

Baron Liebig made a few observations on a new mode of making bread introduced into Germany. Lime-water had been used in the preparation of the dough, and the loaf was rendered still more nutritive than that made by the common mode.

Baron Liebig handed in for inspection a large bar of the new and interesting metal Aluminium.

On the Commercial Uses of Lichens. By Dr. A. L. Lindsay.

On the Chemical Composition of the Waters of the Clyde. By Stevenson Macadam, *Ph.D., F.R.S.E., F.C.S., Lecturer on Chemistry, Surgeons' Hall, Edinburgh.*

This communication is the first of a series which the author has undertaken in order to determine the chemical composition of the rivers of Scotland. The present examination was confined to the river and firth of Clyde, from Dalmarnock Bridge down to Arran. Specimens of the water at the more prominent stations were procured by the author, and separately analysed. Three points were determined, viz. 1. the specific gravity; 2. the amount of saline matter; and 3. the quantity of chlorine.

The following table contains the results of the analyses of the various waters:—

LOW WATER.	Specific gravity.	1000 grains. Saline matter.	Chlorine.
Dalmarnock Bridge	1000·25	0·28	0·02
Rutherglen Bridge Green Suspension Bridge } ...	1000·28	0·30	0·03
Suspension Bridge	1000·40	0·45	0·06
Broomielaw	1000·60	0·67	0·10
Lower Quay	1000·60	0·66	0·10
Govan	1000·59	0·64	0·10
Renfrew..........................	1000·62	0·70	0·15
Kilpatrick	1000·9	1·12	0·60
Bowling..........................	1001·3	1·62	0·79
Dunbarton........................	1002·3	2·92	1·61
Ditto, 1 mile below	1005·8	7·38	4·03
Ditto, 2 miles below............	1007·3	9·36	5·18
Port-Glasgow	1011·3	14·42	7·96
Greenock	1021·8	27·87	15·48
Ditto, + Helensburgh	1018·9	24·53	13·59
Helensburgh	1020·4	26·02	14·46
Row	1022·1	28·24	15·63
Roseneath	1022·1	28·29	15·64
Shandon	1022·3	28·35	15·82
Rahane	1022·4	28·52	15·91
Gairloch-head	1022·4	28·49	15·91
Greenock + Kilcreggan	1020·2	25·77	14·31
Kilcreggan.......................	1021·9	28·06	15·53
Cove	1021·8	27·84	15·47
Portinstuck	1022·7	28·97	16·09
Lochlong + Lochgoil	1022·8	29·02	16·14
Arrochar	1005·4	6·86	3·78
Strone	1022·4	28·51	15·88
Kilmun	1022·1	28·26	15·62
Sandbank	1021·8	27·85	15·48
Lazaretto	1022·3	28·36	15·80
Gourock..........................	1021·9	27·97	15·52
Ditto, + $\frac{2}{3}$ Kirn	1022·9	29·23	16·31
Kirn	1024·3	31·02	17·23
Dunoon	1024·3	31·06	17·24
Inellan	1023·6	30·12	16·88
Toward Point	1023·3	29·70	16·54
Rothesay	1022·5	28·68	15·97
Ascog..............................	1024·2	30·98	17·16
Kilchallan Bay	1024·4	31·16	17·41
Garroch-head	1024·9	31·72	17·69
Corrie	1026·6	33·98	18·91
Brodick	1026·3	33·66	18·72
Millport...........................	1025·6	32·72	18·34
Fairley	1025·6	32.68	18·23
Largs..............................	1025·4	32·46	18·08
Wemyss Bay	1025·6	32·71	18·25
Innerkip	1024·1	30·83	17·08
HIGH WATER.			
Bowling...........................	1006·4	8·14	4·38
Renfrew..........................	1001·6	2·02	1·09

The author does not regard the above figures as expressing the standard mean composition of the Clyde waters at all seasons. Many circumstances will tend to affect these results, such as a wet or dry season determining the greater or less volume of fresh water carried down by the river, and the ebbing or flowing of the tide. The effects

of the latter are well seen in the instances of Bowling and Renfrew, where water of a similar composition is found, at Bowling during every ebb of the tide, and at Renfrew during flood-tide. The distance between these two places is five miles; hence at every ebb and flow of the tide, there is a five-mile variation in the composition of the water at these points. In passing further down the Clyde, no doubt this five-mile oscillation in the strength of the water will vary, but at all the places mentioned in the table it will be more or less apparent.

On the Composition of Bread. By Dr. Maclagan.

Dr. Maclagan gave the results of some experiments which he himself had made. The amount of moisture in bread was less, and consequently the nutritive value greater, than was generally allowed. The late Prof. Johnston had stated that a sack of flour produced one hundred quartern loaves. But, according to his (Dr. Maclagan's) examination, the sack of 380 lbs. gave 94¼ loaves of bread; 100 lbs. of flour giving 231 lbs. of bread. The majority of bakers were of opinion that the sack produced on an average 92 loaves, and there was no great discrepancy between this and the result of his own analysis. Unfermented bread contains, of dry flour, 60; moisture, 10; water added by baker, 30. 100 lbs. of flour will give 143 lbs. of bread, and a sack of flour will yield 100½ quartern loaves of unfermented bread.

On the Metals of the Alkaline Earths. By A. Matthiessen, *Ph.D.*

Dr. Matthiessen has succeeded in preparing the metals strontium and calcium in the form of metallic reguli. The mode of preparation was illustrated by the apparatus used, and beautiful specimens of the metals, sealed up in tubes containing roach oil, and free from all air, were circulated among the members of the Section. Specimens of Lithian wire, prepared by Prof. Bunsen, at whose laboratory at Heidelberg the foregoing metals were prepared, were also exhibited.

On the possibility of representing by Diagrams the principal Functions of the Molecules of Bodies. By the Rev. J. G. Macvicar, *D.D., Moffat, Dumfriesshire.*

In this communication, the author, setting out with a point in the centre of a circle (Dalton's diagram for hydrogen and the astronomical diagram for the sun) to stand for the unit of material nature or minim element out of which all the molecules of bodies might be conceived to be constructed, proceeded to show that nothing more was required in order to arrive at constructions representative of hydrogen, oxygen, sulphur, &c., both as to atomic weight, refractive power, &c., but to combine these unit elements or atoms in such a way as to give a symmetrical construction.

Then showing that the law of symmetry (which alone he postulated as the grand law of natural synthesis) culminated towards a spherical shell or cell as its limit, he proceeded to combine the representatives of the undecomposed bodies he had constructed, so that the compound should always be more nearly spherical than its constituents when separate; and thus he obtained diagrams which proved to be representatives of vapour, water, monohydrated sulphuric acid, &c.

He concluded by illustrating the practical value of his method by presenting before the Section diagrams of urea and uric acid, from which it appeared that their transformation was, under the law of genesis according to maximum symmetry, quite a definite problem.

On the Chemical Composition of some Iron Ores called 'Brass' occurring in the Coal-Measures of South Wales. By E. Chambers Nicholson *and* David S. Price, *Ph.D., F.C.S.*

The ores to which this paper refers are held in low estimation, and even rejected by some ironmasters. It was with a view of explaining the reason of this that their examination was undertaken.

There are three varieties of this ore.

I. One is compact, heavy, and black from the admixture of coaly matter; when broken it exhibits a coarse pisiform fracture.

II. Another is compact and crystalline, not unlike the dark-coloured mountain limestone of South Wales in appearance.

III. The third variety is similar in structure to the first-named. The granules, consisting of iron pyrites, are mixed with coal, and apparently cemented together by a mineral substance of like composition to the two foregoing.

It is from the yellow colour of this last variety that the name 'brass' has been given to the ores by the miners.

The following is their composition :—

	I.		II.	
Carbonate of iron	68·71	= iron 33·3	59·73	iron = 28·83
Carbonate of manganese	0·42		0·37	
Carbonate of lime	9·36		11·80	
Carbonate of magnesia	11·80		15·55	
Iron pyrites	0·22		trace	
Phosphoric acid	0·17		0·23	
Coaly matter	8·87		9·80	
Clay			2·70	
	99·55		100·18	

	III.
Carbonate of iron	17·74
Carbonate of lime	14·19
Carbonate of magnesia	12·06
Iron pyrites	49·72
Phosphoric acid	trace
Coaly matter	6·10
	99·81

The ores I. and II., to which attention is directed as being those to which the remarks apply, may be classified with the spathose carbonates of iron. The absence of clay, and the difficulty, from ignorance of this fact, that would in consequence be experienced in smelting these ores, sufficiently explain the reason of the disrepute in which they have hitherto been held; for when judiciously treated in the blast-furnace, they smelt with the greatest facility, and afford an iron equal to that produced from the argillaceous ores. It will be evident, from the large amount of lime and magnesia which they contain, that their employment must be advantageous in an economic point of view.

An interesting feature in these ores is their fusibility during calcination on the large scale. When this process is conducted in heaps, the centre portions are invariably melted. This, considering the almost entire absence of silica, is apparently an unexpected result.

The fused mass is entirely magnetic and crystalline. Treated with acids, it dissolves with great evolution of heat.

The following is its composition :—

Protoxide of iron	38·28
Sesquioxide of iron	32·50
Protoxide of manganese	0·38
Lime	12·84
Magnesia	13·87
Phosphoric acid	0·17
Sulphur	0·23
Silicic acid	1·20
Alumina	0·51
	100·08

From the above analysis, it is probable that its fusibility is owing to the magnetic oxide of iron acting the part of an acid.

When thoroughly calcined and unfused, the ores retain their original form, and if exposed to the air for any length of time, crumble to powder from the absorption of water by the alkaline earths.

On the Marine Aërated Freshwater Apparatus. By Dr. NORMANDY*.

On a simple Volumetric Process for the Valuation of Cochineal. By Dr. F. PENNY, *F.R.S.E., Prof. of Chemistry, Andersonian University, Glasgow.*

Within the last few years several eminent chemists have rendered important service to the arts by devising simple and expeditious processes for estimating the value of technical products. In the application of volumetric methods of analysis their labours have been most successful.

The great aim has been to combine economy of time with simplicity of manipulation and accuracy of result. The variety and extent of these investigations may be sufficiently indicated by referring to the processes of chlorimetry, to Bunsen's beautiful method for iodine, Marguerite's process for iron, Liebig's process for chlorine and urea, Pelouze and Schwarz's processes for copper, the assaying of silver according to Gay-Lussac, the employment of bichromate of potash for the estimation of iron, tin, iodides, &c., and the recent methods of testing the potash-prussiates.

In this field of inquiry, however, much still remains to be done, both as regards the improvement of the methods already in use, and the extension of our powers by the application of new processes. The discovery of trustworthy methods of determining the economic value of madder, cochineal, oak-bark, logwood, and of many other articles, is a boon still to be desired, and the attainment of which is confidently expected from the progress of technical chemistry.

Several processes have been proposed for testing cochineal. The high price and variable quality of this article, as well as its liability to accidental impurity and occasional adulteration, render the discovery of a suitable method exceedingly desirable.

The adulterations of cochineal have frequently been noticed. The use of sulphate of baryta and bone-black was detected and exposed many years ago. It has also been adulterated with powdered talc and carbonate of lead, and it has at times been found mixed with a coloured paste, moulded into small grains, to resemble, as closely as possible, the form and outline of the insect itself.

Ground cochineal is occasionally adulterated with spent or exhausted cochineal; and Persoz states that the entire insect, exhausted more or less with water acidulated with vinegar, has been dried and sold, or mixed with sound cochineal.

The substance called 'Garblings,' the refuse from riddling or sifting cochineal, has likewise been added to the article in bulk.

As imported, the principal impurities are sand, fibrous organic matter, and a resinous substance resembling seed-lac.

Of the different methods that have been suggested for ascertaining the tinctorial powers of cochineal, the simplest consists in exhausting a known weight with water, and examining the liquor, made up to a certain volume by the addition of water, in the colorimeter, according to the method proposed by Labillardière for madder and indigo.

Berthollet estimates the comparative richness of cochineal in colouring matter by dosing a known quantity, dissolved in water, with a standard solution of chlorine.

An ammoniacal solution of alum has also been proposed for the volumetric valuation of cochineal. The insect in fine powder is exhausted with water, and the liquor and washings, being concentrated by evaporation, are treated with a standard solution of alum, until the whole of the colouring matter is precipitated. From the proportion of alum liquor used the comparative quality of the cochineal is easily determined.

Brokers and others estimate the value of cochineal by boiling a few grains of the sample† with a slip of flannel for a quarter of an hour, in water to which small quantities of cream of tartar and chloride of tin are added. The flannel is afterwards washed and dried, and according to the shade and intensity of the scarlet colour communicated, the value of the cochineal is judged of.

The process now proposed, though far from fulfilling all that could be wished, has been found extremely useful in comparing different samples of cochineal, and has proved equally serviceable in examining specimens of lac-dye, than which few commercial substances are more variable in quality.

It is based on the well-known bleaching properties of red prussiate of potash in

* This invention is patented, and is employed in the Navy and at Heligoland.

† Normandy, Commercial Analysis.

presence of a free alkali. The powers of red prussiate of potash as a discharger or bleacher of organic colouring principles have been successfully applied by Mercer*, and its action as an oxidizing agent fully examined and explained by Playfair, Baudrault†, Wallace‡, and others. Its rapid action upon the colouring matter of cochineal may be seen by adding a solution of the salt to cochineal dissolved in a weak ley of caustic potash or soda, when the rich purple colour of the cochineal liquor will be speedily discharged.

In applying this action to testing the quality of commercial samples of cochineal, certain precautions require to be strictly observed, and of these the most important are, to use the solution of cochineal perfectly cold, and to finish off the process as quickly as possible.

Process.—A fair quantity of the sample being finely pulverized, 20 grains are weighed out, and gently heated in a beaker with half an ounce of caustic potash solution and one ounce of water. When the colouring matter is completely dissolved, one ounce of cold water is added, and the mixture allowed to cool.

An alkalimeter is made up with 5 grains of pure and dry red prussiate of potash in the usual way. This solution is then dropped into the cochineal liquor till the rich purple colour is discharged, and the liquor assumes a yellowish-brown tint. The moment when this effect is produced may be easily ascertained by occasionally spotting a little of the liquor upon a white slab. The number of measures consumed shows the comparative richness of the sample in available colouring matter.

In applying this method to lac-dye, the operations are the same as for cochineal, except that a larger quantity of the lac must be employed, as the amount of colouring matter in it is small compared with that in cochineal.

The accuracy of this process may of course be easily vitiated by the presence or addition of any substance that acts chemically upon the agent of valuation. But nearly all volumetric methods of analysis are open to this objection; and hence they cannot be considered as intended for the use of those who have not sufficient chemical knowledge to guard against such obvious sources of error.

On the Manufacture of Iodine and other Products from Kelp. *By* Dr. F. Penny, *F.C.S.*

In the course of his remarks, Dr. Penny stated that the results of some hundred tests showed the quantities of the several ingredients found in kelp to be as follows:—In good drift weed—soluble matter 75, insoluble matter 22, water 3, iodine per ton 14 lbs., potash salts 7 cwt. In the inferior drift-weed, which had been adulterated with sand and stones, the proportions were—soluble matter 40, insoluble matter 50, water 10, iodine 2 lbs., potash salts 3¾ cwt. In cut weed, the proportions were—soluble matter 60, insoluble matter 35, water 5, iodine 2½ lbs., potash salts 5½ cwt. The average production from a ton of kelp was, from drift-weed kelp—iodine 12 lbs., muriate of potash 4¾ cwt. (80 per cent.), sulphate of potash 2¾ cwt. (55 per cent.), alkaline or fished salt 2¾ cwt., and refuse sulphur ½ cwt. From cut-weed kelp the production was—iodine 2½ lbs., muriate of potash 3½ cwt. (75 per cent.), sulphate of potash 2½ cwt. (30 per cent.), alkaline or fished salt 3½ cwt., and refuse sulphur ½ cwt.

On the Composition and Phosphorescence of Plate-Sulphate of Potash. *By* Dr. Fred. Penny, *F.C.S., Prof. of Chem., Andersonian Inst., Glasgow.*

[This paper may be referred to in Phil. Mag. Dec. 1855.]

On a Process for obtaining Lithographs by the Photographic Process. *By* Professor A. C. Ramsay, *F.R.S.*

Prof. Ramsay described a process by which Mr. Robert M'Pherson, of Rome, had succeeded in obtaining beautiful photo-lithographs,—specimens of which had been hung up in the Photographic Exhibition in Buchanan Street. The steps of the process are as follows:—1. Bitumen is dissolved in sulphuric acid, and the solution is poured on an ordinary lithographic stone. The æther quickly evaporates, and leaves a thin coating of bitumen spread uniformly over the stone. This coating is sensitive to light,

* Chem. Soc. iii. † Journ. Pharm. vii. ‡ Quart. Journ. vol. vii.

a discovery made originally by M. Niepce of Chalons. 2. A negative on glass, or waxed-paper, is applied to the sensitive coating of bitumen, and exposed to the full rays of the sun for a period longer or shorter according to the intensity of the light, and a faint impression on the bitumen is thus obtained. 3. The stone is now placed in a bath of sulphuric æther, which almost instantaneously dissolves the bitumen, which has not been acted upon by light, leaving a delicate picture on the stone, composed of bitumen on which the light has fallen. 4. The stone, after being carefully washed, may be at once placed in the hands of the lithographer, who is to treat it in the ordinary manner with gum and acid, after which proofs may be thrown off by the usual process.

Prof. Ramsay then proceeded to state, that the above process, modified, had been employed with success to etch plates of steel or copper, without the use of the burin:—1. The metal plate is prepared with a coating of bitumen, precisely in the manner noticed above. 2. A positive picture on glass or paper is then applied to the bitumen, and an impression is obtained by exposure to light. 3. The plate is placed in a bath of æther, and the bitumen not acted upon by light is dissolved out. A beautiful negative remains on the plate. 4. The plate is now to be plunged into a galvano-plastic bath, and gilded. The gold adheres to the bare metal, but refuses to attach itself to the bitumen. 5. The bitumen is now removed entirely by the action of spirits and gentle heat. The lines of the negative picture are now represented in bare steel or copper, the rest of the plate being covered by a coating of gold. 6. Nitric acid is now applied as in the common etching process. The acid attacks the lines of the picture formed by the bare metal, but will not bite into the gilded surface. A perfect etching is thus obtained.

On the Composition of Vandyke-Brown. *By* Thos. H. Rowney, *Ph.D., F.C.S.*

This pigment is of organic origin, and is obtained from the peat beds in Cassel in Germany. It is a brown earthy-looking substance, a little heavier than water. It was found to be an organic acid with about 6·00 of earthy matter. The formula deduced from the analyses is $C_{54}H_{20}O_{24}$. It is very soluble in alkaline solutions, and forms salts with various metals and alkaline earths. Being a distinct mineral, the name Vandykite is proposed for it.

On the Composition of two Mineral Substances employed as Pigments. *By* Thos. H. Rowney, *Ph.D., F.C.S.*

In this communication two new minerals are described which have for some considerable time been employed as pigment, but had not previously been described. The first, called Indian red, is brought from the Persian Gulf. It occurs as a coarse powder of a deep red colour; its sp. gr. is 3·843. By analysis it was found to be a silicate of iron, having the formula $Fe_2O_3+SiO_3$. This corresponds in constitution to xenolite, which is a silicate of alumina of the formula $Al_2O_3+SiO_3$.

The second mineral, called raw sienna, is obtained from Sienna. It is a soft earthy substance, of a brownish-yellow colour; its sp. gr. is 3·46. It is hydrated silicate of iron containing a small quantity of alumina, and has the formula $4(Fe_2O_3, Al_2O_3)+SiO_3+6HO$. The name proposed for it is Hypoxanthite; in constitution it resembles opaline allophane, and Schrötterite.

Hypoxanthite	$4(Fe_2O_3, Al_2O_3)$	$+SiO_3+6HO$
Opaline allophane ...	$4Al_2O_3$	$+SiO_3+18HO$
Schrötterite............	$4Al_2O_3$	$+SiO_3+16HO.$

On certain Laws observed in the mutual action of Sulphuric Acid and Water. *By* Balfour Stewart.

The object of this paper is to show that in mixtures of sulphuric acid and water there is a distinct dependence on the chemical equivalents of these substances, and several hydrates are indicated.

The method of analysis used is applicable to other solutions.

When sulphuric acid combines with water the space occupied by the compound is less than that occupied by the ingredients when uncombined, and consequently the

specific gravity of the mixture is greater than it would have been had no contraction taken place.

Assuming the specific gravity of strong liquid acid to be 1·8485 (that of water being 1), we may find what ought to be the specific gravity of any mixture of acid and water, did no contraction take place.

By Dr. Ure's table we can tell the *actual* specific gravity of such a mixture.

Dividing this by the former, we have the proportional condensation.

The proportional condensation is greatest for strength 73 of Dr. Ure's table, which denotes a hydrate composed of 1 equivalent liquid *acid* and 2 equivalents of water.

Let us now suppose all mixtures stronger than a *given* mixture to be formed by the combination of that mixture with liquid acid, and all mixtures weaker than it to be formed by its combination with water.

If we call this *given* mixture our *standard*, and take its specific gravity from Dr. Ure's table, we shall, by means of it, be referred to new proportional condensations different from those already alluded to.

Taking as our *standards* strengths 40, 43 and 45, we are referred to a maximum of condensation at strength 73, as before.

Taking as our *standards* strengths 50, 53 and 55, we are referred to a maximum between strengths 84 and 85, denoting a hydrate composed of 1 equivalent of liquid acid and 1 equivalent of water.

Taking as our *standards* strengths 38, 40 and 45, we are referred to a maximum at strength 82, denoting probably a hydrate composed of 5 equivalents of liquid acid and 6 equivalents of water.

From this it appears, that were we to use as standards all the 100 strengths in Dr. Ure's table, we should be referred to maxima of condensation the number of which would be much less than 100. May we not infer, that when liquids or other substances mix with each other in all proportions, all strengths of such mixtures may be viewed as derived from definite compounds having a tendency to combine with their components and with each other, thereby forming other compounds, so that at length mixtures of any strength may be produced?

It might be advantageous to lay off the different strengths in Dr. Ure's table as abscissæ of a curve, of which the corresponding proportional condensations (for a given standard) are the ordinates; thus the irregularities would become apparent.

It might also be advantageous to apply this analysis to metallic alloys and amalgams, where it would probably indicate those possessed of properties the most marked.

On the Condition of the Atmosphere during Cholera.
By R. D. Thomson, *M.D., F.R.S.*

The chemical condition of cholera atmospheres is a question of intense interest in the subject of public health; but, with the exception of the unpublished experiments of Dr. Prout in 1832, comparatively little attention appears to have been bestowed on it. One of the most striking circumstances connected with the occurrence of the disease is, that no change very palpable to the senses prevails, and even one may have remarked that the weather has usually been exceedingly agreeable. In London, at St. Thomas's Hospital, the neighbourhood of which afforded a large supply of cholera cases, the relative weight of the air in August 1854, a cholera month, and in August 1855, when the metropolis was in an extremely healthy condition, is exhibited in the following table, in grains per cubic foot:—

1854. Week ending	Weight of cubic foot in grains.	1855. Week ending	Weight of cubic foot in grains.
August 5 ...	522·9	August 4 ...	516·9
„ 12 ..	526·7	„ 11 ...	524·3
„ 19 ...	525·0	„ 18 ...	525·9
„ 26 ...	523·5	„ 25 ...	519·2
Sept. 2 ...	525·1	Sept. 1 ...	523·0
„ 9 ...	530·3	„ 8 ...	531·6
Mean......	525·6	Mean......	523·5

The result, as deduced from this table, which has been calculated approximately from the barometric pressure and dry- and wet-bulb thermometer, is analogous to that obtained by Dr. Prout in 1832, as the author was informed by himself. Corresponding observations have been made at Greenwich by Mr. Glaisher, and the same conclusions arrived at; from which it would appear that this superior weight of a given bulk of air was not a local phænomenon, but was diffused to considerable distances. The character distinguishing September 1854 from the corresponding period in 1855, was the absence of any atmospheric action on ozone test-paper in the former season, while during the present year the oxidizing influence of the air has never been absent at St. Thomas's Hospital. During September 1854, however, when no ozone could be detected in London, its action was sometimes faintly and often very strongly marked at Lewisham, near Greenwich. Throughout the same periods the air was exceedingly stagnant; and it has since been observed by Mr. Glaisher, and also at Vienna, that rapid atmospheric movement is pretty constantly accompanied by an oxidizing condition of the air. With reference to the chemical composition in the atmosphere of inhabited localities and of malarious districts, experiments have usually been conducted on the constitution of the gases which enter into the composition of the air. But the results seem to have thrown little light on the possibility of the production, from such causes, of any disease characterized by a regular sequence of symptoms. So far as our knowledge warrants, gases can either act only as asphyxiating media by the exclusion of oxygen, or as slow or rapid poisons. The cause capable of inducing a disease formed on a peculiar type, analogy leads us to infer must be an organized condition, either in a solid form or in a finely diffused or vaporific state. The fact observed, that in malarious atmospheres sulphuric acid speedily becomes black, also points to the propriety of examining the air in such situations, with the view of filtering from it solid or condensable matter. In the epidemic of 1849–50, the author examined the exterior air of an infected district with this object in view, to the extent of many cubic feet; but the result was comparatively negative, and led to the inference that the examination of large masses of air could alone hold out any prospect of a successful issue. For this purpose air was passed through carefully prepared distilled water, contained in Woulfe's bottles, by means of a large aspirating apparatus of the capacity of 16 cubic feet, which was kept constantly in action during the day for several months. Occasionally, freezing mixtures were applied to portions of the apparatus, and a tube filled with pumice moistened with sulphuric acid placed next the aspirator completed the series. A range of tubes conducted the air from a cholera ward into the aspirator. The ward was 32 feet long, 20 feet wide, and 9 feet high. The air was drawn from the centre of the ward near the ceiling; and when the apartment was filled with cholera patients, the air, after traversing several layers of distilled water, was speedily charred by the sulphuric acid, previously depositing a variety of solids in all the Woulfe's bottles, which could even be detected in some measure by the eye. The objects consisted of blue and red cotton fibres from the dresses of the inmates, portions of hair, wool, fungi, sporules of fungi, abundance of vibriones or lower forms of animal life, with particles of silica and dirt. In this and all the experiments conducted on the air of closed apartments, the distilled water was rendered strongly acid from the presence of sulphuric and sulphurous acids derived from the products of gas and coal combustion. The distilled water employed in these experiments was boiled for some time previous to being introduced into the apparatus, and was divided into two portions; one part being placed in a stoppered bottle beside the Woulfe's bottles through which the air was conducted, the sediment, if any, being afterwards examined and compared with that resulting from the experiment. When the ward was partially full, vegetable epiderm, vegetable cellular tissue, fragments of wood, cotton, linen, vegetable hairs, a sponge spicula, minute fungi, spiral vessels, sporules, spore cases, animal epithelium, oil-globules, and siliceous particles were detected; while vibriones were entirely absent, or at least mere traces could be discriminated. This is an interesting result, since in the first case only 98·6 cubic feet were examined, and of the partially empty ward 240 cubic feet passed through the apparatus. When the ward was empty, cotton fibres, wool, a trace of fungus with carbonaceous and siliceous particles were alone discernible, the amount of air examined being 304 cubic feet. The air external to the ward and in the immediate neighbourhood afforded, from 560 cubic feet, one cotton fibre, one of wool, a crystalline body (probably a sponge spicula), sporules, beautiful mycelia of fungi in various stages of development, and some carbonaceous matter. The distilled water

in this instance likewise yielded a strongly acid reaction, produced by sulphur acids. The possible influence of sewer atmospheres predicated interesting results from an examination of such air; and accordingly it was found that the predominating feature of this experiment was animal life in the form of swarms of vibriones in various stages of advancement. The chemical reaction in this case, unlike that in the preceding experiments, was invariably alkaline, due to the evolution of ammonia from the nitrogenous matters contained in the sewage liquors. These experiments render it sufficiently obvious that organic living bodies constantly surround us in close apartments, and particularly that animal matter under certain circumstances is likewise diffused through such atmospheres. They fail to point out any matter capable of communicating cholera from one individual to another through the medium of the air, and therefore are highly important to the public; but they show that foreign animal matter injurious to health may speedily be concentrated in certain localities, which will undoubtedly assist in the production and propagation of disease in conjunction with meteorological conditions. Pathological investigations, carefully conducted by the author's colleague, Mr. Rainey, detected in one case an entozoon in the glottis or upper part of the air-passage, the only analogue of which has been found in the substance of the muscle of animals, which would seem to indicate that the germ of this creature had been derived from the atmosphere, or at least from external sources.

It is intended that these experiments, which are tedious and laborious in their character, shall be extended to other atmospheres, so as to obtain comparative series of views, so to speak, of air modified by the influence of different diseases.

On Caseine, and a method of determining Sulphur and Phosphorus in Organic Compounds in one operation. By Dr. Aug. Vœlcker, *Prof. of Chemistry in the Royal Agricultural College, Cirencester.*

When milk is mixed with a saturated solution of common salt and heated, the caseine coagulates like albumen, and separates almost completely, if sufficient salt-solution has been employed.

The caseine, thus separated from milk, washed, dried, and exhausted with alcohol and æther, on analysis furnished the following results:—

Carbon	50·97
Hydrogen	7·43
Nitrogen	15·09
Oxygen	17·99
Sulphur	1·15
Phosphorus	·39
Ash	6·98

The ash consisted chiefly of phosphate of lime, which rendered it doubtful whether or not there was any phosphorus present in another state, as that of phosphoric acid.

With the view of determining this point, the impure caseine obtained with common salt was dissolved in dilute caustic ammonia, the solution filtered and precipitated with acetic acid. It was then washed with cold distilled water, dried, and again extracted with alcohol and æther. Dried at 110° C., it furnished, on combustion with chromate of lead, the following results:—

		Ash deducted.
Carbon	53·43	53·61
Hydrogen	7·12	7·14
Nitrogen	15·36	15·47
Oxygen	21·92	21·99
Sulphur	1·11	1·11
Phosphorus	·74	·74
Ash	·32	
	100·00	100·00

It was thus remarkably free from inorganic matters, and the phosphorus mentioned

in the analysis cannot therefore have occurred in the caseine in the form of a phosphate, but must have existed in it in a peculiar state of organic combination. This amount of phosphorus is equal to 1·70 of phosphoric acid, a quantity nearly six times as large as the whole amount of ash in the sample of caseine analysed.

In caseine prepared at different times, invariably free phosphorus, amounting from ·50 to ·75 per cent., was detected.

The method employed for determining sulphur and phosphorus in caseine, in one operation, was the following:—

About 18 grs. of the dried and finely powdered caseine was mixed with six times its weight of a mixture of pure carbonate of soda and nitre, and this mixture introduced in small quantities into a large red-hot silver or platinum crucible. The white fused mass was dissolved in hydrochloric acid, and the sulphuric acid thrown down with chloride of barium. From the weight of the sulphate of baryta the sulphur was calculated. The excess of baryta was next removed with pure sulphuric acid, after which the acid liquid was supersaturated with caustic ammonia, which precipitated a small amount of phosphates. The ammonia precipitate was collected on a filter, washed, dried, and weighed. The filtrate was finally mixed with an ammoniacal solution of sulphate of magnesia, which threw down the phosphoric acid; produced under the oxidizing influence of nitre from the organic phosphorus contained in the caseine.

Comparative experiments with sugar and the same oxidizing mixture employed in the phosphorus-determination of caseine, gave only negative results, and thus showed that there was no phosphorus present in any form in the mixture of carbonate of soda and nitre.

On some of the Basic Constituents of Coal-Naphtha. By C. GREVILLE WILLIAMS, *Assistant to* DR. ANDERSON, *Glasgow University.*

In this paper, which forms part of a series of researches on the volatile organic bases, the author shows, that although the points of difference between the gelatinous tissue of bones, cinchonine, coal, and bituminous shale, are as well marked as it is possible for them to be, that, nevertheless, the volatile alkaloids produced by their destructive distillation are almost identical, thus:—

Gelatinous Tissues.	*Cinchonine.*	*Coal.*	*Dorset Shale.*
Pyrrol*.	Pyrrol†.	Pyrrol§.	Pyrrol¶.
Pyridine*.	Pyridine†.	...	Pyridine**.
Picoline*.	Picoline†.	Picoline‖.	Picoline¶.
Lutidine*.	Lutidine†.	...	Lutidine¶.
Collidine*.	Collidine†.	...	Collidine¶.
...	Chinoline‡.	Chinoline§.	Parvoline ¶.
Aniline*.	Lepidine‡.	Aniline§.	

Three intervals are seen to exist in the coal series, namely pyridine, lutidine, and collidine. The author proceeds to show, that by a careful fractional distillation of the bases obtained by treatment of crude naphtha with sulphuric acid, and subsequent distillation of the acid liquid with lime, fluids may be obtained boiling at 242°, 310°, and 345° Fahr. He converted these fractions into platinum salts, which on analysis gave numbers almost exactly agreeing with those required by theory for the three bases last mentioned.

As a further confirmation of the identity of the pyridine from coal-tar with that from bone-oil, he transformed the platinum salt by protracted boiling with water into the bihydrochlorate of platino-pyridine,

$$\left.\begin{matrix} C^{10}\,H^{1} \\ Pt \end{matrix}\right\} 2HCl,$$

the per-centage of platinum corresponding closely with that required by the formula.

* Anderson, Trans. Royal Soc. Edinb., vol. xvi. part 4; vol. xx. part 2; and vol. xxi. part 1.

‡ Gerhardt, Revue Scientif., vol. x. p. 186.

† Greville Williams, Trans. Royal Soc. Edinb., vol. xxi. part 2.

§ Runge (1834), Poggendorff's Annalen, vols. xxxi. & xxxii.

‖ Anderson, Trans. Royal Soc. Edinb., vol. xvi. part 2.

¶ Greville Williams (1854), Quart. Journ. Chem. Soc. Lond.

** Greville Williams (1854), Phil. Mag.

On a Process for obtaining and purifying Glycerine, and on some of its Applications. By G. F. Wilson.

The manner in which it is prepared is by placing a piece of common fat in a quantity of supersaturated steam; the fat is decomposed, and resolves itself into two substances, viz. an acid and glycerine. The latter, having a taste like sugar, is applicable to the cure of burns, rheumatism, and ear diseases; it is a substitute for cod-liver oil, and also for spirits of wine; also for the preservation of flesh; and can be applied to photography, and preserving animals in their natural colours.

GEOLOGY.

On the condition of the Haukedalr Geysers of Iceland, July, 1855. *By* Robert Allan, *F.R.S.E., F.G.S. &c.*

The Geysers of Iceland, like most volcanic phænomena in other regions, are changeable in their action, and from time to time alter in their character and appearance. Some of them, it is a well-ascertained fact, are steadily increasing in activity and intensity, while others are as distinctly growing weaker. Those of Haukedalr, towards the south-western extremity of the island, are the hot springs best known to us; and although there can be little question that they fall under the category of diminishing Geysers, their action is still powerful, and their structure most remarkable. These Geysers, according to well-authenticated Icelandic history, came into existence in the fifteenth century, namely, in the year 1446. What phænomena attended their eruption at that period we are not informed, but their action is understood among scientific men in Iceland, to have been then and long after much more powerful than it now is; nor is the statement made by Olavsen and Paulson, that the eruption of the Great Geyser in the year 1772 rose to the height of 360 feet, however incredible in our eyes, disbelieved by well-informed men in that country.

But coming down to our own times, and taking facts upon which there can be no possible doubt, we still find the description and drawings of these Geysers, as detailed by each successive visitor who has published any account of them during the current century, differ materially in particulars. Sir George Mackenzie's narrative, in 1810, is a faithful and interesting one; but the changes which have occurred in the intervening forty-five years are sufficiently remarkable to render them worthy of record.

The entire area of these hot springs cannot exceed sixteen or twenty acres, and its extreme length from north to south is not above a quarter of a mile. They are situated at the foot of Langarfiall, a crag about 300 feet high, upon rather elevated flat ground, commanding a wide open view over a fine verdant plain to the east and south, Blafell and other mountains partly capped with snow rising to the north with great magnificence. Even the white point of Hecla may be distinguished in this locality some thirty miles distant.

This area or field slopes to the south, and also falls away towards the river on the east, so that the Great Geysers is situated not only towards the northern, but also on the higher portion of the ground. The Strokr is distant about 120 yards southward of the Geyser; and the little Strokr perhaps 100 yards still farther south and in nearly a direct line. These are the three principal springs at present erupting, and although there are from forty to fifty other apertures in the vicinity, and particularly towards the lower or southern extremity of the field, some of which emit water with violent ebullition and much noise, yet to these three alone can the title of either Geyser or Strokr be properly applied—the former, that is the Geyser, meaning "Agitator," and the latter, or Strokr, being the common Icelandic name for a churn. To the Strokrs the appellation of Roaring Geyser and New Geyser are given by previous travellers; but as this rather tends to confusion, we shall retain the names given them by the peasantry, about which there can be no misapprehension.

On still higher ground than even the Geyser, and more towards the aforemen-

tioned crag, are two tremendous holes or underground caverns, 30 or 40 feet deep, filled and seething over with boiling water of the most perfect limpidity. These are coated to their edge with a thin crust of earth or crumbly rock; and although really beautiful objects, such vast caldrons can scarcely be gazed into from so unsound a margin without a certain feeling of awe. Several of the holes in the lower portion of the field are of a similar description, being, in fact, irregularly shaped caverns, quietly running over with boiling water, which to their bottom is as clear as crystal, and of a fine light green hue. In one of them we observed large bubbles, probably a foot in diameter, rapidly evolved, and rising in one direct line from some lower region to another higher up, but which did not ascend to the surface; nor could we perceive that they had any direct communication with other orifices in the vicinity, although undoubtedly some such existed. Some of the smaller holes bubble out water with much noise, and six of these, we noticed, close to others perfectly limpid, emitted boiling mud.

The paramount objects, however, of this wonderful locality are the Geyser and the two Strokrs, and to these we shall confine our remarks.

The Geyser is the only one of the three which has formed a mound or siliceous deposit round its orifice. From the sloping nature of the ground this mound is more than one-half higher on the east than it is on the west side, and extends three or four times farther in the former than it does in the latter direction, attributable, probably, to the greater prevalence of westerly winds in this locality.

The western side may be 15 to 20 feet in height, the eastern can be little short of 25 or 30. The northern, the western, and the southern are comparatively abrupt, while that on the east slopes away gradually; but throughout, they form one mass of siliceous deposit, which is roughened on the surface with what, at a little distance, might be taken for an irregular circular flight of steps. The section of the Geyser may be compared to a funnel, its pipe or orifice resembling the stalk, and its cup or basin the head of that utensil. The cup is nearly round, its diameters taken in opposite directions being 72·6 and 68·1; while its depth, measuring perpendicularly from a line drawn across its margin, appeared to be nearly 4 feet. The pipe we ascertained to be 83·2 in depth, and rather more than 10 feet in diameter. Under ordinary circumstances, when the Geyser is quiescent, this cup and pipe are filled to the brim with limpid hot water, which ever and anon, but at totally irregular periods, boils up in the centre, and then the water runs over, principally at the points where the lip is a few inches lower than elsewhere in the circle. This is a mere abortive attempt; when, however, an eruption takes place, which almost invariably is preceded by a premonitory subterranean rumbling noise, resembling the looming of distant cannon, and by a trembling of the earth under foot, these ebullitions rise higher, first in a mass of 2 or 3 feet, which opens in the centre, and surges outwards like a wave, and then the water is suddenly ejected into the air, with the velocity and din of some hundred sky-rockets, the entire mound being immediately overflowed. This occurred four times during the thirty-six hours we were on the spot, two of these eruptions being on the grandest and most brilliant scale; which, after waiting patiently for no less than twenty-seven hours, without the slightest appearance of action, we were fortunate enough to witness, the first at half-past eleven at night, the other at six the following morning. After an eruption, the water recedes in the pipe, and not only is the cup left entirely dry, but 8 or 10 feet of the pipe is likewise emptied. The inside of the pipe appears perfectly smooth, and is nearly circular; but the cup, or upper portion of the funnel, as well as the entire mound outside of it, are both covered with siliceous incrustations, deposited by the water, and doubtless still more by the volumes of steam or spray arising from it. Inside of the cup, these incrustations present a smooth, dull ash-gray coloured crust, dotted with occasional pure white concretions of extreme beauty. When broken up, this crust yields an exceedingly hard sinter, bearing considerable resemblance in colour, when cut and polished, to some varieties of madrepore. Outside the mound, these incrustations assume the figure of cauliflower heads, and many other forms, which, although deposited perfectly white, shortly become gray; and which, notwithstanding their being as entirely siliceous as those of the hard sinter inside the cup, are too porous and fibrous in their structure to admit of being polished. But the finest specimens of these incrustations are to be found at some of the smaller orifices lower down the field, where they are much varied in colour, structure, and

appearance; often so extremely fragile, as to crumble on being handled, and occasionally forming mere coatings of the most delicate description, on vegetable or bony matter—nay, even upon portions of clothing material, or scraps of writing or printed paper.

Both of the Strokrs differ from the Geyser in being mere round holes or pipes, neither funnel-shaped at their orifices nor raised above the surface of the ground. They likewise differ from it in the fact that they afford no premonitory symptom of a coming eruption—no previous warning, but all at once dart into the atmosphere with extreme violence. The depth of the Strokr approximates to that of the Great Geyser—being, according to our measurement, $87\frac{1}{2}$ feet, but the diameter of its pipe is rather under 9 feet.

Shortly after our arrival, the guides cut about a barrowful of turf, which they threw into this Strokr. This at first apparently stopped the violent ebullitiou which can be seen always going forward in this remarkable spring at the depth of 10 or 12 feet, but in the course of ten minutes it began to roar, and then we had an instantaneous and truly magnificent eruption. The water did not appear in a column, as most fountains do, but in a continued intermittent series of many jets all at one moment, having different forces, and unitedly presenting one grand pyramidal jet d'eau of the most symmetrical and graceful description. Calculating from a little distance in proportion to the figures standing by it, we were satisfied that some of the principal ejections on this occasion—and there were fully thirty of them, lasting in all about ten minutes—must have been from 90 to 100 feet in height, and darkened as the water naturally appeared from the turf thrown into it, the effect was exceedingly striking. About twelve hours afterwards we repeated the dose, but the Strokr would not act until it received a double allowance, and then it did so much to the same effect as previously, throwing up stones and portions of the turf to its highest elevation. Three times subsequently during our short stay it erupted spontaneously, but on none of the occasions was it so fine as when provoked by our feeding it with turf. The Little Strokr is very violent and very noisy. Its eruptions are feathery and extremely beautiful, although it rarely rises above 30 feet, and from the less regular form of its orifice, is not so symmetrical as its larger namesake.

The action of these hot springs during eruption is not that of a mass of water driven up in column, as the description and drawings of most previous visitors would lead one to expect. The old print published by Sir John Stanley so far back as 1789 comes nearer to what we witnessed than anything bearing more recent date. Instead of a column, it is rather that of a multitude of jets possessing different intensities, all working simultaneously; so that, whilst a few of them rise perpendicularly and attain the highest elevation, others having less power apparently stop short, and others again, being slightly inclined, are thrown out somewhat obliquely—all this, be it remembered, at one and the same moment, the jets intermitting, altering, and repeating their action with the utmost rapidity, and affording to an onlooker, on a quiet day, one of the most sublime and magnificent objects in nature. No doubt the ejection from the orifice of the pipe takes place in a columnar mass. This we distinctly observed it did at the Great Geyser, to the height of 10 to 15 feet above the rim of the cup; but being accompanied, as these eruptions of boiling water naturally are, by vast volumes of steam, and withal so rapidly changeful in their movements, it is not easy to ascertain exactly what goes on near the orifice at the moment of propulsion. But under no circumstance did this column, as it issued 10 feet diameter from the mouth of the pipe, remain long in that form. It surged outwards, and was immediately forced up in jets, which, rising abruptly above the volumes of steam, broke in the most graceful feathery masses in every direction. Stones thrown in, and particularly the masses of turf with which we supplied the Strokr, were driven out to the highest extremity of these jets, some of them falling outwards, and others dropping into the vortex, and being a second or a third time driven into the atmosphere. How all this takes place—the structure of the machinery which causes such magnificent action—or, in fact, what goes on underground, it is not my province to speculate upon.

I close these remarks by noticing a few of the recent changes which are observable in this locality. Sir John Stanley in 1789 found the pipe of the Geyser 61 feet deep, and $8\frac{1}{2}$ in diameter. The funnel, or basin, as he terms it, is stated at that period to have been 8 feet in depth and 60 feet in diameter. "Both of these," he says, "have

been evidently formed by gradual deposition from the water, and a mound round them has in like manner been formed 30 feet high, and extending in various directions to distances of 80, 100 or 120 feet." The great eruptions, which by theodolite he ascertained to rise 96 feet, took place every two hours, and lasted 15 to 20 minutes. The Strokr he states to be 6 feet 10 inches in diameter, and its eruption to be much more columnar than that of the Geyser, and rising to the height of 132 feet. In 1810 Sir George Mackenzie found the pipe 60 feet deep and 10 in diameter, and its basin only 3 feet deep, and from 46 to 58 feet across—the configuration of the latter in his time not being round, but indented, as it were, at one side. The Geyser eruption he estimated as rising to 90 feet, and the periods of its action were more frequent than now. The Strokr, Sir George says, played magnificently to the height of 70 feet for half an hour at a time. Henderson, in 1815, who paid the locality two visits, estimated the Geyser eruption at 150 feet, and that of the Strokr as even higher than 200 feet. The French in 1836 made the depth of the Geyser 75½ feet, the breadth of the basin 52½, the height of its eruptions 105, and the diameter of the pipe 16 feet. The Strokr they noticed to rise to the height of 92 feet, and the diameter of its pipe they give at 8 feet, and its depth at 65 feet.

Professor Bunsen, in 1846, who spent eleven days upon the locality, found the Geyser about 66 feet deep, and estimated its eruption at 140 up to 177 feet. The Strokr, he says, is 43 feet deep, and only 7 in diameter, and he estimated its eruption at 160 feet. Comparing these descriptions and measurements with each other and with our own, it is pretty evident, that whether the intensity of the eruptions of these Geysers be greater or less now than they have been during the past seventy years, they assuredly have fallen off exceedingly, both in their frequency and in their duration. No doubt the action is more powerful at one time than another, or at one season than another; indeed it is believed to be more so in damp and wet weather than during dry seasons. The supply of water to the springs must vary, and the evaporation at the surface, dependent on the currents of air, may also have its effect upon their action. Still, that the quantity of water emitted from them on the whole is much less than it once was, there can be no question.

Sir John Stanley found the great eruptions of the Geyser take place every two hours. Henderson, in 1815, says that the Geyser erupted in the most imposing manner every six hours. We waited twenty-seven hours before anything of the kind occurred; and the eruptions of the Strokr, which Sir George Mackenzie gazed upon for half an hour at a time, never now last above eight or ten minutes. Another obvious change has been going forward, and is still progressing, in the mound of the Geyser, arising from the rapid deposit of siliceous matter upon its sides. The edge of this mound forms the rim of the circular cup, which Sir John Stanley and Sir George Mackenzie both describe as about 60 feet across. This has now extended, still however in a nearly circular form, to no less than 68 by 72, and the size and bulk of the mound must have correspondingly increased. On the whole, such decided changes upon the aspect of these Haukedalr Geysers leave little doubt that their action is becoming rapidly weaker, and that the time may not be far distant when their forces, like those of Hecla in the vicinity, will become nearly quiescent. There are other similar hot springs in the island, especially to the north, which are known, on the contrary, to be steadily increasing; and I am sanguine of having it in my power shortly to place in the hands of our scientific men a detailed account of some of these to us hitherto almost unknown Geysers in Iceland.

On the Superficial Deposits laid open by the Cuttings on the Inverness and Nairn Railroad. By George Anderson.

On the recent Discovery of Ichthyolites and Crustacea in the Tilestones of Kington, Herefordshire. By Richard Banks. *Communicated by the President.*

The discovery of fossil fishes and minerals, highly illustrative portions of the crustacean *Pterygotus*, by Mr. R. Banks, was adverted to by Sir R. Murchison, the detailed description of which was referred to the Geological Society of London.

Notice of the Discovery of Ichthyosaurus and other Fossils in the late Arctic Searching Expedition, 1852–54. *By* Captain Sir EDWARD BELCHER, *C.B.*

The position where the remains of the Ichthyosaurus were found on the summit of Exmouth Island, about 700 feet above the sea-level, is in lat. 77° 16′ N., and long. 96° W. The upper stratum of limestone is about 30 feet in thickness, dipping at an angle of 7° westerly. The inferior stratum is of red sandstone of a deep red colour, which gave to the island, in the first instance, the name of Red Island.

The base of the island is of a friable disintegrating sandstone, which has been worn away on all sides, leaving the concentric elevation equal to one-third of its original diameter, and rising so abruptly from its base as to be accessible only on its western end.

These fossils were examined by Professor Owen, and described as follows:—

"The specimens submitted to me by Captain Sir Edward Belcher, which form the subjects of plate 31, are fossil remains of vertebræ and portions of ribs of an Ichthyosaurus.

"Figs. 1, 2, and 3 represent the largest and best preserved fossil, which is the body of an anterior abdominal vertebra. It presents the ichthyic character of the concavity of the articular surface on both the front and back part of the centrum *c*; with the character of co-existing diapophyses *d* and parapophyses *p*, not known in fishes, but which the *Enaliosauria* present in their anterior trunk-vertebræ, in common with the *Dinosauria, Crocodilia,* and other highly-organized reptiles. The generic characters of the Ichthyosaurus are manifested in the shortness (*i. e.* the relatively small fore and aft diameter) of the centrum as compared with its breadth and height, and in the shape of the neurapophysial surfaces *n p*, and their proportions to the free neural surface *n*. With regard to the specific character of this vertebral centrum, its proportions pretty closely accord with those of the *Ichthyosaurus acutus* from the Whitby lias; but this would be quite inadequate ground for a reference of the Arctic Ichthyosaur to that species in the absence of any evidence of the shape of its skull and dentition.

"Figs. 4 to 7 are of a terminal caudal vertebra, of the natural size, apparently of the same species of Ichthyosaur and probably from the same individual as the vertebræ figs. 1–3, from the more advanced part of the body.

"The small caudal vertebra equally manifests the Ichthyosaurian characters in its degree of biconcavity and in the form of the neurapophysial pits *n p*; the lateral compression of the centrum indicates the vertebral development of the tegumentary tail-fin it helped to support: on the under surface are four surfaces for the hæmal arches, which are articulated, as in the Crocodiles, at the vertebral interspaces to two contiguous centrums.

"Figs. 8 to 11 are portions of ribs. The long, free, thoracic-abdominal pleurapophyses, or vertebral ribs, of the Ichthyosaurus are peculiar for the deep longitudinal groove which impresses them on each side, giving to their transverse section the form represented in fig. 10. Two fragments of ribs, figs. 8 and 9, found associated with the before-described vertebræ, present this grooved character, and, with the vertebræ, afford cumulative proof of the Ichthyosaurian nature of the Arctic fossils represented in plate 31*."

It was on the centre of the island, at its highest pitch, and at a vertical bluff where a cairn was constructed, that these remains, accompanied by other fossils, were noticed; and at the last moment, on finishing the pile, two specimens were presented by one of the men, apparently fossil bones; but, from anxiety to proceed and save the season, were hastily thrust into the pocket, and consigned, with others, for future scrutiny.

It is remarkable that no fossiliferous limestone is met with on the westernmost cliff of Exmouth Island, nor on any of the lands outside of an oval space which would include Princess Royal Island, and the cliffs adjacent—on an axis of twenty-five miles; nor do any further traces of fossils of any description re-appear until

* Impressions of the Plates referred to were presented to the Association.

reaching the entrance of Cardigan Strait, in 76° 38′ N., where they only occur in boulders on the beach; and the next position southerly is Cape Eden, in 75° 30′, where the 'Assistance' wintered in 1853–54.

On the Glacial Phænomena of the Lake District of England. *By* JAMES BRYCE, *F.G.S.*

Mr. Bryce pointed out the peculiar geological structure of the district, illustrated by a coloured map. There are three granitic districts, encircled by slate of three different ages, the granites and slates being all very distinct and easily recognized when found in remote places. These rocks are found to be transported to great distances, in various directions, across valleys and over high ridges, and the cause adequate to produce the phænomena is a matter still in dispute among geologists. In order to elucidate, if possible, this obscure subject, Mr. Bryce had carefully examined the many mountain valleys radiating in all directions from the high mountain mass of the Great Gabel, and found various evidences of the former action of glaciers in all these valleys. They seem to have descended from a nucleus in the higher bosoms of the mountains, to have filled the valleys, and spread out over the low country at the base, all round the lake district. In confirmation of this view, various arguments were stated, and the directions of the striæ pointed out on a map on which they had been laid down by the compass.

On a lately discovered Tract of Granite in Arran. *By* JAMES BRYCE, *F.G.S.*

On sections of Fossils from the Coal Formation of Mid-Lothian. *By* ALEXANDER BRYSON.

Ancient Canoes found at Glasgow. *By* JOHN BUCHANAN, *Glasgow.*

The very considerable number of these primitive vessels, discovered from time to time at Glasgow, belonging to the wild people who inhabited this part of Scotland at a period long antecedent to the dawn of British history, is not a little remarkable, and seems fairly entitled to some consideration, not merely as raising curious moot points in archæology, but as tending to reflect glimmerings of light, feeble though these may be, on the physical condition of the locality in which a great city now stands, at an epoch so deep in the dark night of Time, as to be, to us, utterly unknown.

Without, however, entering at present upon archæological topics, I shall confine myself to a narrative of the facts connected with the canoe discoveries. And here I may observe that I happened to possess favourable opportunities for personally inspecting the greater number of these ancient boats, through the courtesy of the late Mr. David Bremner, the talented engineer on the river Clyde, who sent me timely notice of each discovery, and thus enabled me to see them while *in situ*.

Within the last eighty years, no less than seventeen canoes have been revealed at Glasgow. This little ancient fleet was of the most primitive kind. Each boat was formed out of a single oak-tree. Some were more rudely shaped than others, and had evidently been hollowed out principally by the action of fire, assisted by blunt tools, probably of stone. All had the aspect of great antiquity.

The physical position of Glasgow is in a valley, several miles wide, through which the Clyde pursues its course from east to west, expanding into an estuary about twenty-five miles distant. The more ancient portion of the city is built on a ridge of considerable elevation, about a mile north from, and nearly parallel with, the river. From this stony ridge descend several successive terraces, or deserted sea-beaches, having a general direction the same as the ridge. A number of the streets of the more modern part of Glasgow have been formed along, and the houses face these terraces. When dug into, either in the construction of common sewers, or otherwise, they are found to be composed of finely laminated sand, as if it had been deposited in tranquil, and probably deep water.

Now, *five* of the canoes were discovered on, or near these terraces, under the streets, viz. one near the bottom of the ridge; two within a few yards of each other at the City Cross, on a lower terrace, one whereof was in a vertical position with the prow uppermost as if it had sunk in a storm, and had within it a number of marine shells; a fourth was dug out further down the slope; and the fifth under what is now St. Enoch's parish church, within 200 yards from, and at an elevation of about ten feet above the river bank, being the lowermost terrace. In this last canoe was a stone hatchet, still preserved. The three first-mentioned boats lay at points far above all river action, and could not have been drifted by the mere stream of the Clyde to their resting-places.

The remaining twelve canoes were discovered within the last ten years, still lower down, during extensive operations for improving and widening the harbour. Large portions of the river banks were cut away, and these canoes were found. They lay in groups in a very thick bed of finely laminated sand, on the lands of Springfield, Clyde-haugh, Bankton, &c., at an average depth of about twenty vertical feet, and at a distance of more than 100 yards back from the river edge, as laid down in the oldest maps. One of these canoes had gone down prow foremost, and was sticking in the sand at an angle of 45 degrees; another had been capsized, and lay bottom uppermost; all the rest were in a horizontal position, as if they had sunk in smooth water.

These facts seem to warrant the conclusion that, at the time the canoes floated, a sea or estuary, several miles wide, and reaching far up the country, existed at what is now Glasgow, washing the base of the hills on both sides of the valley; and that this ancient sea retired either by the recession of the waters, or the elevation of the bottom, by degrees, with long pauses between, which occasioned the formation of the terraces, or deserted beaches already noticed. The tide is still perceptible three miles above Glasgow, at the little burgh of Rutherglen, where a canoe similar to those described in the outset was found in 1830, at a considerable elevation, and a long way back from the river, as recorded in the 'New Statistical Account of Scotland,' vol. vi. p. 601.

On the Auriferous Quartz Formation of Australia. By J. A. Campbell.

Mr. Campbell was of opinion that the gold fields are inexhaustible, and the finding of gold only in its infancy. Boundless fields lie still untouched, which will employ the labour of ages yet to come, when efficient machinery shall have been brought to operate upon the rocks.

On Denudation and other effects usually attributed to Water. By Robert Chambers, *F.G.S.*

On the Probable Maximum Depth of the Ocean. By W. Darling.

Mr. Darling suggested, that as the sea covers three times the area of the land, it is reasonable to suppose that the depth of the ocean, and that for a large portion, is three times as great as the height of the highest mountains.

On the Fossils of the Coal Formation of Nova Scotia. By J. W. Dawson, *Principal of MacGill College, Montreal.*

[The paper was illustrated by a rich collection of specimens.]

Mr. Dawson said, that the strata of the coal-measures in Nova Scotia extend to a depth of no less than 14,000 feet, containing sixty distinct surfaces, covered with plants and trees. He spoke of the marine and land deposits collected in the deltas, where the roots of the Calamite held together the mud which, forming into flats, sank down to receive others.

Many of the fossil remains described by Mr. Dawson as existing in the coal formations of Nova Scotia are to be found also in the coal-fields of Scotland.

On the Relations of the Silurian and Metamorphic Rocks of the South of Norway. By David Forbes, *F.G.S.*

A number of large sections were exhibited, showing the relative positions of these rocks, and their structure dwelt upon at length. It was shown, by overlooking the foliation of the metamorphic rocks, and by keeping in view the mineral character of the rock masses themselves, that the crystalline rocks of Norway, hitherto considered as irresolvable, would be found conformable to the Silurian formation above them, and that they could be regarded as altered sedimentary rocks, probably analogous to the Cambrian sandstones and shales of Wales.

Some of the hornblende gneiss was even shown to be above the Devonian sandstones, and to correspond to argillaceous shales of other parts of Norway.

It was contended that the felspathic and massive gneiss of the South of Norway was in great part, if not altogether, granite, with a superinduced foliated structure; and the large sections and plans showed full evidence of its having been eruptive.

Remarks on the Cleavage of the Devonians of the South of Ireland. By Professors Harkness *and* Blyth.

The counties of Cork and Kerry present several features of an interesting nature, as far as regards cleavage. Beds affording this structure are intimately associated, and interstratified with others which are devoid of cleavage; and from several analyses it would appear that the cleaved strata possess a greater amount of alumina than such deposits as want this structure. The specific gravity of the cleaved strata is also greater than where this mode of arrangement does not occur.

The angle of the cleavage planes varies with the chemical composition of the rock in which this structure appears; the greater the proportional amount of alumina, the greater is the angle of cleavage.

In the county of Cork the strike of the cleavage planes accords with the strike of the rolls, which the Devonian strata have in this district been subjected to, and is in an east and west direction. In the county of Kerry the same circumstance obtains, but here the strike of the roll is not so regular as in the former county. In the island of Valentia the intimate connexion which exists between the operations of the force producing rolls and that from whence cleavage originates is well seen. Here the strikes are E. and W., E.N.E. and W.S.W., and N.N.E. and S.S.W., and with these several strikes the planes of cleavage agree. The cleavage is also most perfect in those localities where the rolls are best developed, and all the features presented by the cleavage of the Devonians of the south of Ireland support the inference that this structure owes its origin to that force which has subjected the deposits to a series of rolls; and that those beds exhibit this structure best which were originally of a soft shaly nature, being composed of particles capable of rearranging themselves at right angles to the planes of pressure.

On the Lowest Sedimentary Rocks of Scotland. By Professor Harkness, *F.G.S.*

The axis of the lower Silurians of the south of Scotland traverses the counties of Roxburgh and Dumfries, and in connexion with this axis are found the lowest sedimentary rocks of Scotland. The nature of the strata composing the axis is arenaceous; and beds of this character are well seen in the course of the Dryffe water in the latter county. These beds are overlaid both on their north and south side by thin bedded greywacke sandstones and shales which are much flexured, and in one locality afford *slaty* beds, which seem to be the result of the flexures to which the strata have been subjected. At Brinks in Roxburghshire the thin greywacke shales afford evidence of the existence of animal life in the form of tracks of animals traversing mud, and these tracks bear the appearance of having resulted from crustaceans. They are the earliest traces of animal life which have yet been detected in Scotland. The same beds also are marked by desiccation cracks, furnishing the earliest direct proofs of the existence of dry land. They are likewise gently rippled, and seem to have originated from littoral conditions. Some higher beds contain *Protovirgularia*, and above these are found the graptolite shales, which have previ-

ously been regarded as the base of the fossiliferous rocks of Scotland. The purple grits, which form the axis, have a continuous E.N.E and W.S.W. course. On the north side the strata dip N.N.W., and on the south side S.S.E.

On the Geology of the Dingle Promontory, Ireland. *By* Professor HARKNESS, *F.G.S.*

The county of Kerry is for the most part occupied by Devonian strata, and good sections of them are seen on the coast between Slea Head at the north entrance into Dingle Bay and Sibyl head, the southern point of Tralee Bay. Devonian strata are not, however, the exclusive beds in the interval occupied by these points, for at Donquin and Ferriters cove deposits of a different mineral nature make their appearance, and these abound in upper Silurian fossils. Both on the north and south side of the Silurian areas, and also in the space which separates them, there occur deposits of purple slate overlaid by conglomerates; and those on the south side of the Silurians dip south at the same angle with the latter formation, and on the north side they appear to pass under the Silurians also, at the same dip. This mode of occurrence seems to result from rolling of the strata, the deposits being pushed over towards the north. The sequence of strata in this district appears to be perfect from the upper Silurians below through some strata appertaining to the Devonians above; and in this portion of Ireland we have as yet the only beds which have been recognized as upper Silurian in Ireland.

On the Meridional and Symmetrical Structure of the Globe, its Superficial Changes, and the Polarity of all Terrestrial Operations. *By* EVAN HOPKINS, *C.E.*, *F.G.S.*

On the Gold-bearing Districts of the World. *By* E. HOPKINS, *C.E.*, *F.G.S.*

Mr. Hopkins's paper contained the results of his observations on the auriferous districts of the world, in which he stated that gold was found only in the primary rocks, and chiefly in quartz, because, when the gold was precipitated, as it were, in nature, the quartz was that with which its particles most readily mixed. Gold might be found in all primary rocks of a meridional structure, where crystalline sands predominate. It was a curious fact, that gold might often be found at the roots of large trees, because the roots having assimilated for nourishment the other materials, left the gold as an indigestible surface behind.

On the Formations of Dalmatia. *By* Signor LANZA.

On the Excavation of certain River Channels in Scotland. *By* C. MACLAREN, *F.G.S.*

On the less-known Fossil Floras of Scotland. *By* HUGH MILLER.

Scotland has its four fossil Floras: its Flora of the Old Red Sandstone, its carboniferous Flora, its oolitic Flora, and that Flora of apparently tertiary age, of which His Grace the Duke of Argyll found so interesting a fragment under the thick basalt beds and trap tuffs of Mull. Of these, the only one adequately known to the geologist is the gorgeous Flora of the coal-measures, probably the richest, in at least individual plants, which the world has yet seen. The others are all but wholly unknown. How much of the lost may yet be recovered I know not; but the circumstances that two great Floras—remote predecessors of the existing one—that once covered with their continuous mantle of green the dry land of what is now Scotland, should be represented but by a few coniferous fossils, a few cycadaceous fronds, a few ferns and club-mosses, must serve to show what mere fragments of the past history of our country we have yet been able to recover from the rocks, and how very much in the work of exploration and discovery still remains for us to do,

We stand on the further edge of the great Floras of bygone creations, and have gathered but a few handsfull of faded leaves, a few broken branches, and a few decayed cones.

The Silurian deposits of our country have not yet furnished us with any unequivocal traces of a terrestrial vegetation. Professor Nicol of Aberdeen, on subjecting to the microscope the ashes of a Silurian anthracite which occurs in Peebles-shire, detected in it minute tubular fibres, which seem, he says, to indicate a higher class of vegetation than the algæ; but these may have belonged to marine vegetation notwithstanding.

Associated with the earliest ichthyan remains of the Old Red Sandstone, we find vegetable organisms in such abundance, that they communicate often a fissile character to the stone in which they occur. But existing as mere carbonaceous markings, their state of preservation is usually so bad, that they tell us little else than that the antiquely-formed fishes of this remote period had swum over sea-bottoms darkened by forests of algæ.

The immensely developed flagstones of Caithness seem to owe their dark colour to organic matter, mainly of vegetable origin. So strongly bituminous, indeed, are some of the beds of dingier tint, that they flame in the fire like slates steeped in oil. The remains of terrestrial vegetation in this deposit are greatly scantier than those of its marine Flora; but they must be regarded as possessing a peculiar interest, as the oldest of their class in, at least, the British Islands, whose true place in the scale can be satisfactorily established.

In the flagstones of Orkney there occurs, though very rarely, a minute vegetable organism, which the author has elsewhere described as having much the appearance of one of our smaller ferns, such as the maidenhair spleenwort or dwarf moonwort. But the vegetable organism of the formation, indicative of the highest rank of any yet found in it, is a true wood of the cone-bearing order.

"I laid open the nodule which contains this specimen, in one of the ichthyolite beds of Cromarty, rather more than eighteen years ago; but, though I described it, in the first edition of a little work on 'The Old Red Sandstone' in 1841, as exhibiting the woody fibre, it was not until 1845 that, with the assistance of the optical lapidary, I subjected its structure to the test of the microscope. It turned out, as I had anticipated, to be the portion of a tree; and on my submitting the prepared specimen to one of our highest authorities, the late Mr. William Nicol, he at once decided that the 'reticulated texture of the transverse section, though somewhat compressed, clearly indicated a coniferous origin.' I may add, that this most ancient of Scottish lignites presented several peculiarities of structure. Like some of the Araucarians of the warmer latitudes, it exhibits no lines of yearly growth; its medullary rays are slender, and comparatively inconspicuous; and the discs which mottle the sides of its sap-chambers, when viewed in the longitudinal section, are exceedingly minute, and are ranged, so far as can be judged in their imperfect state of keeping, in the alternate order peculiar to the Araucarians. On what perished land of the early Palæozoic ages did this venerably antique tree cast root and flourish, when the extinct genera *Pterichthys* and *Coccosteus* were enjoying life by millions in the surrounding seas—long ere the Flora or Fauna of the coal-measures had begun to be?"

The Caithness flagstones have furnished one vegetable organism apparently higher in the scale than those just described, in a well-marked specimen of Lepidodendron, which exhibits, like the Araucarian of the Lower Old Red, though less distinctly, the internal structure. It was found about sixteen years ago in a pavement quarry near Clockbriggs—the last station on the Aberdeen and Forfar Railway—as the traveller approaches the latter place from the north. Above this gray flagstone formation lies the Upper Old Red Sandstone, with its peculiar group of ichthyic organisms, none of which seem specifically identical with those of either the Caithness or the Forfarshire beds; for it is an interesting circumstance, suggestive surely of the vast periods which must have elapsed during its deposition, that the great Old Red system has its three distinct platforms of organic existence, each wholly different from the others. Generically and in the group, however, the Upper fishes much more closely resemble the fishes of the Lower, or Caithness and Cromarty platform, than they do those of the Forfarshire and Kincardine one. In the upper-

most beds of the Upper Old Red formation in Scotland, which are usually of a pale or light yellow colour, the vegetable remains again become strongly carbonaceous, but their state of preservation continues bad—too bad to admit of their determination of either species or genera; and not until we rise a very little beyond the system do we find the remains of a Flora either rich or well-preserved. But very remarkable is the change which at this stage at once occurs. We pass at a single stride from great poverty to great wealth. The suddenness of the change seems suited to remind one of that experienced by the voyager when, after traversing for many days some wide expanse of ocean, unvaried save by its banks of floating sea-weed, or where, occasionally and at wide intervals, he picks up some leaf-bearing bough, or marks some fragment of drift-weed go floating past, he enters at length the sheltered lagoon of some coral island, and sees all around the deep green of a tropical vegetation descending in tangled luxuriance to the water's-edge—tall, erect ferns, and creeping Lycopodiaceæ; and the Pandanus, with its aërial roots and its screw-like clusters of narrow leaves; and high over all, tall Palms, with their huge pinnate fronds, and their curiously aggregated groups of massive fruit.

"In this noble Flora of the coal-measures much still remains to be done in Scotland. Our Lower Carboniferous rocks are of immense development; the limestones of Burdie House, with their numerous terrestrial plants, occur many hundred feet beneath our mountain limestones; and our list of vegetable species peculiar to these lower deposits is still very incomplete. Even in those higher carboniferous rocks with which the many coal-workings of the country have rendered us comparatively familiar, there seems to be still a good deal of the new and the unknown to repay the labour of future explorers. It was only last year that Mr. Gourlie, of this city, added to our fossil Flora a new Volkmannia from the coal-field of Carluke; and I detected very recently in a neighbouring locality, though in but an indifferent state of keeping, what seems to be a new and very peculiar fern. There is a Stigmaria, too, on the table, very ornate in its sculpture, of which I have now found three specimens in a quarry of the coal-measures near Portobello, that has still to be figured and described. In this richly-ornamented Stigmaria the characteristic areolæ present the ordinary aspect; each, however, forms the centre of a sculptured star, consisting of from eighteen to twenty rays, or rather the centre of a sculptured flower of the Composite order, resembling a garden daisy. The minute petals—if we are to accept the latter comparison—are ranged in three concentric lines, and their form is irregularly lenticular. Even among the vegetable organisms already partially described and figured, much remains to be accomplished in the way of restoration. The detached pinnæ of a fern, or a few fragments of the stems of Ulodendron or Sigillaria, give very inadequate ideas of the plants to which they had belonged in their state of original entireness."

Exhibition of Fossil Plants of the Old Red Sandstone of Caithness. Collected by JOHN MILLER *of Thurso.*

These plants, chiefly collected from the upper portion of the Caithness flags near Thurso, appeared to be the same as those described in detail by Mr. Hugh Miller. Some of the specimens were of considerable dimensions and great beauty.

On the Relations of the Crystalline Rocks of the North Highlands to the Old Red Sandstone of that Region, and on the recent discoveries of Fossils in the former by Mr. Charles Peach. *By* Sir RODERICK I. MURCHISON, *Director-General of the Geological Survey.*

Having referred to his earliest publications relating to the Old Red Sandstone, in 1826 and 1827 (associated in the latter year with Prof. Sedgwick), the author explained how the classification originally proposed by his colleague and himself had been extended and improved by the researches of Mr. Hugh Miller. Having stated that his matured and condensed views, showing the true equivalents of the Old Red Sandstone to be the Devonian rocks of other countries, were given in his last publi-

cation, entitled 'Siluria,' Sir Roderick called the special attention of the Section to the consideration of the true relations of these deposits to the crystalline rocks of the Highlands. To satisfy his mind on this point, and to see if it was necessary to make any fundamental change in his former views, the author re-surveyed his old ground in Sutherland, Caithness, and Ross-shire, accompanied by Prof. James Nicol. Obtaining ample evidence to induce him to adhere to his former opinion, that all the crystalline rocks of that region, consisting of gneiss, mica-schist, chloritic and quartzose rocks, limestones, clay-slate, &c., were originally stratified deposits, which had been crystallized before the commencement of the accumulation of the Old Red Sandstone, he first gave a rapid and general sketch of those ancient rocks, whose crystalline character he attributed to a change of their pristine sedimentary condition. They have a prevalent strike, varying from N.E. and S.W. to N.N.E. and S.S.W., and in the northernmost counties of Scotland their usual inclination is to the E.S.E. or S.E., usually at high angles.

In combating a theoretical idea, which had recently been applied to the crystalline rocks of Scotland, viz. that many of their apparent layers were simply a sort of crystalline cleavage, by which the different minerals were arranged in parallel folia or laminæ, and were independent of the original lines of deposit, he showed how the geologists who had longest studied these rocks in Scotland had formed a different opinion. Hutton, Playfair, Hall, Jameson, M'Culloch, and Boué, all believed, as well as Professor Sedgwick and himself, that the variously constituted and differently coloured layers of these rocks truly indicated separate deposits of sand, mud, and calcareous matter. He also cited numerous cases of interstratified pebble beds and limestones as completely demonstrative of their original status. Alluding to the real distinction between stratification and cleavage, he expressed his belief that, whilst in scarcely any part of the Highlands which he had seen, did there exist that perfect and symmetrical cleavage which prevails in North Wales, there was, nevertheless, a very marked and prevalent division of these Highland crystalline rocks into rhombic and other forms by rude cleavages and decisive joints.

In describing two traverses which he made across these crystalline rock masses in the north coast of Sutherland,—the first, twenty-eight years ago, the other in the weeks preceding this meeting,—and, in mentioning with due praise a memoir, of intermediate date, by the late Mr. Cunningham, it was stated, that the oldest, or lowest visible stratified rock in that region was a very hard, gray, quartzose gneiss, traversed by veins of granite, as seen on the shores of Loch Laxford, Cape Wrath, the escarpment of Ben Spionnach, in Durness, and other places.

At the last-mentioned locality, and near Rispond, the older gneiss is unconformably overlaid by a copious series of quartz rocks, of white and gray colours, occasionally passing into mica-schists or flagstones, and also into stratified masses, which are also *gneissose*, inasmuch as they are composed of quartz, mica, or felspar. With a copious interstratification of bands of limestone, near their lower parts, these crystalline rocks are very clearly exhibited between Loch Durness and the Whiten Head on the coast, or between Ben Spionnach and Loch Eribol in the interior. It is in one of the beds of limestone subordinate to the lower quartzites of this great series, at Balnakiel, in Durness, that Mr. Charles Peach recently discovered organic remains; and, as their discovery has led to certain suggestions, including one which would refer these crystalline rocks to the Devonian or Old Red Sandstone formation, the author shows why such an opinion is untenable. For, whether a section be made across the various strata between Loch Durness and Loch Eribol, or from the latter to Loch Hope, the same limestones, subordinate to quartz rocks of white and gray colours (including some rare coarse white grits, as in the summit of Ben Spionnach), and associated with many siliceous concretions (of various colours, red and dark gray), are distinctly and conformably overlaid by and pass up into micaceous quartzite and dark-coloured schists, both chloritic and talcose, which are followed by other and differently composed stratified masses, having the character of gneiss. Along the north coast, these overlying masses extend to the west shore of Loch Tongue, before they are interfered with by any mass of granite; and it is therefore unquestionably true, that the band of limestone containing the fossil shells discovered by Mr. Peach is a low member of this great crystalline series of stratified rocks of such diversified characters.

It had been suggested, that the fossils in question, being of a whorled form, might prove to be the *Clymeniæ* of the Devonian rocks; but although, according to Mr. Salter, one or two of them have a certain resemblance to that genus, and some even to Goniatites, the evidence of their being chambered shells is too obscure to decide the case. The principal fossil is probably an Euomphalus: it resembles the *Maclurea* or *Raphistoma* of the Lower Silurian rocks, except that the former, to which it most approaches, has a dextral and not a sinistral curve. Even should some of these whorled shells prove to be chambered, there is nothing about them to gainsay their belonging to the *Lituites* of the Lower Silurian rocks. Another fossil is certainly an Orthoceratite.

Sir Roderick then adverted to a feature in the older series of crystalline rocks of the west coast of Scotland, which still required to be more accurately defined than had hitherto been done. Prof. Sedgwick and himself had formerly called attention to the occurrence, near Ullapool, of a red conglomerate or coarse grit, subordinate to the crystalline rocks, but which must not be confounded with the true Old Red, as developed on the north and east coasts of the counties of Caithness, Ross, Inverness, Nairn, Moray, &c. During his excursion of this year, Prof. Nicol and himself saw, near Inchnadampff in Assynt, a similar interposition of hard red conglomeritic grit, resting unconformably on the older gneiss. He pointedly cautioned young geologists not to be led away by the notion that all Scottish conglomerates made up of crystalline pre-existing rocks represented the so-called *old red* conglomerate, and particularly referred to the coarse red conglomerate of Girvan in Ayrshire, which is a part of the Lower Silurian series of the south of Scotland *. Whilst, however, it is probable that some of the red conglomerate of the West Highlands, which is associated with the crystalline rocks, may be also of Lower Palæozoic age, it is clear that the stupendous masses of red sandstone which constitute the mountains of Applecross and Gareloch are of a younger date. Positive proof of this was formerly given by Prof. Sedgwick and himself, from unconformable junctions of the two classes of rock at Ullapool in the West Highlands. On the eastern coasts also, the oldest conglomerate and sandstone of the Ord of Caithness clasps round the quartzose and micaceous rocks of the Scarabin Hills, and is made up of the materials derived from those crystalline rocks which are contiguous to it.

From the immense length of time which must have passed in their accumulation, the vast deposits of the Old Red Sandstone are supposed by the author to be the full and entire equivalents of the Devonian rocks of the south-west of England, of the Rhenish provinces, of large regions in other parts of Germany, as well as of France, Spain, and other countries. He demonstrated the truth of this position by citing the fact, that in Russia, where he had traced such a very extensive range of rocks of this age, regularly interpolated between the Silurian and Carboniferous systems, there occurred in the same beds a mixture of the same species of fossil fishes (*Asterolepis*, *Dendrodus*, *Glyptosteus*, *Bothriolepis*, *Holoptychius*, *Cricodus*, *Pterichthys*, &c.) which prevail in the north of Scotland, with the shells which characterize the formation in the slates and calcareous type which it assumes in Devonshire.

He then announced that, in addition to the fossils previously elaborated and described by Mr. Hugh Miller and other authors, a number of plants had recently been discovered, chiefly by Mr. C. Peach of Wick, but also by Mr. J. Miller and Mr. Dick of Thurso, in the very heart of the Caithness flagstones—the great fish deposit of the series. Of these plants a large number of those which Mr. Peach had submitted to him seemed to be of terrestrial origin. The importance of correctly determining the character of these plants will be at once seen when it is considered that, with the exception of the minute and rare vegetable forms detected by the author in the uppermost Silurian rocks, which form a passage into the Devonian rocks or Old Red Sandstone, these Caithness fossils are probably the oldest known and clearly recognizable land plants; it being believed that the fossil vegetables hitherto found in the so-called Old Red, chiefly occur in the upper member of the system. Such are certain plants discovered by Dr. Fleming and others in Shetland and Orkney, by the geological surveyors in Ireland; and such is the position of that very remarkable and beautiful Flora, detected by M. Richter of Sahlfield in Germany, which is under the description of M. Unger of Grätz †.

* See Quart. Journ. Geol. Soc. vol. vii. p. 152; and 'Siluria,' p. 160.

† Quart. Journ. Geol. Soc. vol. xi. p. 416; and 'Siluria,' p. 358.

In recapitulating, Sir Roderick expressed his conviction that the same series of the older crystalline or metamorphic rocks was several times repeated in the contiguous tracts of Sutherland and Ross by great heaves of the masses,—such breaks being often occupied by the chief lochs or firths. He also dwelt on the very remarkable fact, that in these two northern counties there was an apparent symmetrical succession from older to younger masses in proceeding from west to east. Even the physical watershed of one portion of the region, as seen in the steep precipices of the Bealloch of Kintail, only four miles distant from the western sea, indicated no anticlinal; the flagstones of gneissose rocks there plunging rapidly to the east-south-east. In the more southern portions of the Highlands, and where they usually still preserve the same general strike, these crystalline strata are frequently thrown into anticlinal forms, owing to the powerful intrusion of eruptive rocks; so that from Fort William or Ben Nevis southwards we have first in the porphyry of that mountain, and afterwards in the porphyries and syenites of Glencoe or the granite of Ben Cruachan, as well as in other points still further south, great centres of disturbance, by which the same series of quartzose, micaceous, and chloritic rocks with limestones, but in which clay-slate more prevails than in the north, is repeated in vast undulations, some of which dip to the west-north-west and others to the east-south-east. One of the most southern of these anticlinals may be seen in the centre of Loch Eck, where the masses dip off to Strachur and Inverary on the north-west, and to the Clyde on the south-east.

In conclusion, the author enforced his view of the posteriority of the Old Red Sandstone to all such crystalline rocks by showing (as indeed Prof. Sedgwick and himself had done many years ago) that the coarse conglomerates of the Old Red Sandstone series, not only wrapped round those ancient rocks, but were absolutely made up of their fragments. He further adverted to the great diversity of the strike and dip of the two classes of rock and of their entire unconformity to each other, of which he cited an instructive example at the head of Loch Keeshorn, and the lofty massive mountains of the Old Red Sandstone of Applecross, the beds of which have a steady, slight inclination of 10° or 12° to the north-west, whilst the low flanking and conterminous primary limestones, quartzites, mica-schists and gneissose rocks extending from Keeshorn to Loch Carron plunge rapidly to the east-south-east. In short, whilst the limestone of Durness in Sutherland (identical in its mineral characters and associations with that of Keeshorn in Ross) is of very remote antiquity, the Old Red Sandstone is composed of the regenerated materials of such older rocks, and distinctly overlaps them in discordant positions.

New Geological Map of Europe exhibited. By Sir RODERICK I. MURCHISON, *D.C.L., F.R.S. &c., and* Professor JAMES NICOL, *F.R.S.E., F.G.S.*

This new Map of Europe was stated by Sir R. Murchison to be an extension to Western Europe of the Map of Russia and the conterminous countries, published in the year 1845 by himself and his associates; the same classification being continued.

The chief new feature is the addition of the geology of Spain as prepared by M. de Verneuil. As the previous Map of Russia comprehended by much the largest half of Europe, the present work would have been completed long ago had it not been desirable to postpone it until a due acquaintance with the Iberian peninsula had been obtained.

[The Map is published by Messrs. Johnston of Edinburgh, and may be had separately from the Physical Atlas.]

On Striated Rocks and other Evidences of Ice-Action observed in the North of Scotland. By JAMES NICOL, *F.R.S.E., F.G.S., Professor of Natural History in the University of Aberdeen.*

The author described several evidences of ice-action observed in the north of Scotland during a recent excursion with Sir Roderick I. Murchison. These were, 1st. Striated rocks; the more remarkable instances were the following:—Strath Garve for many miles above Contin, where the sides of the valley are covered with

striæ running from N.W. to S.E.*, parallel to the valley. Strath Bran, also in the direction of the valley, or nearly W. and E. Braambury Hill near Brora, the white siliceous sandstone of the oolite beautifully smoothed and marked with striæ running W. towards Loch Brora and Ben Horn. Large angular masses of the old red conglomerate are still resting on the striated rocks. North coast of Sutherland, near Betty Hill, striæ from E.S.E. to W.N.W. West side of the Kyle of Durness, white quartz-rock with horizontal striæ running N.N.E. to S.S.W. West coast of Sutherland Ridge above Kyle Skow, gneiss polished and striated; direction of striæ E.S.E. to W.N.W.

The most remarkable instance of the dependence of the direction of glacier striæ on local conditions is seen near the Sound of Skye. At the upper extremity of Loch Keeshorn, close to the bridge, the striæ, on the old red sandstone, have a direction from N. to S. parallel to the valley. On the east of the Loch in the valley, followed by the road to Jean Town, the rocks, generally talcose beds of the quartz series, are beautifully marked by striæ running W. by N., or nearly at right angles to the former. On the ridge and on the top of the hills between Balmacarra and Kyle Aiken ferry, the striæ are again from S. by E. to W. by N. At the foot of Keppoch Hill on Loch Duich, an overhanging cliff is very distinctly marked by horizontal striæ from S.E. to N.E in the direction of the lake. Taken in connexion with the Coolin Hills in Skye, shown by Professor James Forbes to be another centre of glacier striæ, these facts show a convergence of ancient ice-streams towards the Sound of Skye.

2nd. The second form of ice-action are transported boulders. Blocks of a very peculiar granite were traced from the valley of the Alness above Ardross Castle, where they are sometimes arranged as it were in moraines, over the whole promontory of the Black Isle to the shores of the Moray Firth. Striated stones were seen in the detritus near Cape Wrath. On the west coast of Sutherland, near Loch Laxford, enormous blocks are often perched on the top of rounded bosses, or on the very verge of precipices, like lines of sentries on the watch. As the slightest impulse seems sufficient to dislodge these boulders, the manner in which they have been placed in their present position is very problematical.

3rd. The third form of ice-action was observed on the coast of Caithness, near the old castle of Wick. The top of the cliff, far above high water for nearly a quarter of a mile, is covered by angular blocks, broken from the rocks below and forced up, in a sloping position one over the other, like shoals of ice on the banks of a river when breaking up after frost. The author ascribes this remarkable accumulation to an iceberg grounding on the shore, and, from the position of the fragments, considers that it must have been moving from the E.N.E. or E.

On the Pterygotus *and Pterygotus Beds of Great Britain. By* D. Page.

Without attempting to define with precision the vertical range of the *Pterygotus* and other associated Crustacea, the author was of opinion that the zone of the "Tilestones,"—partly on the verge of Siluria and partly on the verge of Devonia—might, with no great impropriety, be designated the "Pterygotus beds of Great Britain." At all events, in this zone alone had the remains of *Pterygotus* and other allied Crustacea been found most abundantly; so abundantly, indeed, that these creatures might be regarded as the characteristic fauna of the period. During the last summer, he had examined pretty minutely the relations of the strata in Forfar, Perth, Stirling, Dunbarton and Lanarkshire, and everywhere he had found them maintaining the same stratigraphical position, and characterized by the same fossil fauna. Co-ordinating them in like manner with the Ludlow and Hereford beds (which had yielded fragments of *Pterygotus, Onchus, Plectrodus,* &c.), they appeared to be on the same horizon; and thus it was, he wished to group the whole of these "Tilestone" strata as the "Pterygotus beds of Great Britain." The subject he intended to lay before the Section naturally resolved itself into two divisions; first, what we know of the *Pterygotus* and its crustacean congeners; and, second, the range and limit of the strata in which these crustaceans had been discovered. The

* The directions are true, or corrected for the variation.

remains of the *Pterygotus* have been known in Scotland for more than half a century, the mandibular, or jaw-feet (from their scale-like sculpturing and wing-like shape), being the "Seraphim" of the Forfarshire quarrymen. These and other portions have been in the cabinets of the curious for many years, and were universally regarded as the remains of fishes. Even Agassiz himself looked upon the imperfect fragments originally shown him as ichthyolites; and it was not till he had an opportunity of examining (in 1834) the once magnificent collection of Mr. Webster, of Balruddery, that he discovered their true crustacean character, and at once assigned to them a place in Palæontology, under the title of *Palæocarcinus alatus*; and subsequently, when he saw that the creature had no generic relationship to any existing Crustacea, he abandoned the first name for that of *Pterygotus problematicus*, in allusion to the deceptive nature of the remains. The *Pterygotus*, of which there appeared to be three distinct species,—the gigantic *problematicus*, the *anglicus*, and the *punctatus*—was altogether different in its general structure from any known crustacean, living or extinct. The portions chiefly found (and of these capital specimens were in the collections of Lord Kinnaird, the Watt Institution, Dundee, &c., all originally from Balruddery) were the frontal cephalic shield, the posterior cephalic or thoracic shield, with its lunar-like epimera, the abdominal segments, generally from seven to eleven in number, the huge prehensile claws, with their curious denticulated edges, attached to limbs of great length, the shorter swimming-limbs, with their paddle-like appendages, and several semi-oval detached plates, which evidently belonged to the breast or under side of the animal. Putting all these portions in place, as nearly as could be determined, we had a huge lobster-like crustacean—but only lobster-like in general contour, for in its true generic relations it belonged to no existing family in the order. Partly phyllopod and partly pœcilopod, in its abdominal segmentation macrourous, and in its thoracic apparatus resembling the existing *Limulus*, the *Pterygotus* could be classed with no living family, and was in aspect more like the larval than the adult form of any Crustacea with which we were acquainted. This peculiarity, indeed, ran throughout the whole of the Crustacea (and there were several new forms he would notice on another occasion) which had hitherto been detected in this geological horizon—a horizon that would yet be found to be marked peculiarly by its strange Crustacea. From the portions he now exhibited to the Section, the members could perceive at a glance that the restoration by Mr. M'Coy was altogether erroneous, and bore scarcely any resemblance to what the creature must have been when alive, and acting the part of scavenger along the muddy shores of the Old Red Sandstone seas. The figures on the walls (Mr. Page here exhibited what he conceived to be a near approach to a complete restoration) would afford some idea of the general features of the animal, which he had found of all sizes, from ten or twelve inches up to full five or six feet in length. Such was the *Pterygotus*; and, looking at *its* complex structure, as well as the similar structure of the other Crustacea of the period, there could be no doubt that no existing classification of the order embraced them in its subdivisions. The fact was, that the existing Crustacea were by no means well worked out as a group, and the discovery of these strange fossil forms rendered the study still less perfect. With regard to the *second* portion of his subject, he would only remark, that, without attempting minute co-ordinations, he was inclined to place the "Pterygotus beds" on the very lowest verge of what had hitherto been regarded the Old Red Sandstone or Devonian system. It was true, that some high authorities were inclined to rank these beds as Upper Silurian, that is, on the very highest stage of the Silurian system; and so far as the working out of the beds were concerned, it mattered little whether they were regarded as *lowest Devonian* or *uppermost Silurian*; but this he might observe, that so long as the *Cephalaspis* was regarded as a true Old Red ichthyolite, geologists were bound to rank the Pterygotus beds as the base of that system. In Scotland, the *Cephalaspis* and *Pterygotus* were invariably found in the same strata; and for this reason he had hitherto contended for the "Tilestones" of the English geologists being restored to the Devonian system, where they had originally been placed. Taking this view, we had a well-marked zone of grey fissile flags and tilestones, of slaty marls and laminated shales, everywhere in Scotland and England subjacent to the true "Old Red," and as decidedly superior to the shales and limestones of Siluria, characterized as these were

by the presence of trilobitic Crustacea, and the general absence of ichthyic forms. The Pterygotus beds were well-marked throughout the whole of Forfar, Perth, Stirling, Dunbarton, and Lanark; and he had little doubt that, when more minute research was directed to the subject in England, they would be found to be equally persistent, though marked, it might be, by the presence of additional local forms.

On the Freshwater Limestone of Dr. Hibbert. *By* D. Page.

In introducing this subject, the author remarked, that it was now upwards of twenty years since Dr. Hibbert's elaborate memoir on the Burdie House limestone was read before the Royal Society of Edinburgh. Since that time little had been done to determine the stratigraphical relations and extent of the Burdie House beds; and, though the workings had yielded many fossils, no further attempt had been made to identify their geological horizon with other portions of the great Scottish coal-field. At the time Dr. Hibbert made his researches, the Burdie House limestone was regarded as a peculiar and anomalous deposit; and though its earliest investigator had a clear conception of its inferior position to the marine or true carboniferous limestone, he yet failed to exhibit the continuity and extent of its geographical range, or to connect it with its chronological equivalents in other localities. The result of this has been, that while the Burdie House limestone is often quoted as an instance of freshwater or brackish beds occurring in the carboniferous system, it is as often misplaced, and its real geological bearings misinterpreted. For example, in two of our most recent publications, and these by acknowledged masters of the science, the Burdie House strata are by one placed above the millstone-grit, and by the other are associated with the mountain limestone. Nothing, however, could be more decided than their subjacent position to the true carboniferous limestone. It was a member of the subcarboniferous or lower coal-measure group, and had a range of strike as regular and well-marked as the carboniferous limestone itself. Beginning, for instance, at Burdie House and tracing it to the north-east, it was found at St. Catherine's, at Duddingstone, near Holyrood, crossing the Frith of Forth, in the Island of Inchkeith, then at Pettycur, and westward by Brosiehall, Bin of Burntisland, Newbigging, Starleyburn, Balram, on the shore near Inchcolm House, in the low grounds of Donibristle, at Rosyth, beyond Queensferry, and then re-crossing the Forth, in the parish of Abercorn, at Binny, Kirkton of Bathgate, East Calder, in the Water of Leith, and eastward by the Pentlands to Burdie House. Its outcrop thus presented a large elliptical area, and everywhere dipped at varying distances beneath the true carboniferous or mountain limestone. In fact, when the outcrop of the mountain limestone was traced in the same manner, starting at Gilmerton and Moredun, and thence across the Forth, to Seafield of Kinghorn, and Chapel of Kirkaldy, then westward by Glenniston, Little Raith, Bucklivie, Duloch, Charleston—thence across the Forth by Winchburgh and Bathgate, and then eastward by Midcalder, the Pentlands, and Dryden, to Gilmerton—it presented an almost perfect parallelism and continuity. In fact, the two outcrops exhibited two boldly marked zones on a quaquaversal uprise, of which the Corstorphine Hills might be considered the centre. With the one were associated dark-coloured shales with bands of ironstone, beds of fire-clay, thin seams of coal, and thick-bedded sandstones like those of Craigleith, Burntisland, and St. Andrews; with the others were associated calcareous and bituminous shales, black band and clay, ironstones, seams of coal, and coarse quartzose grits. Such were the stratigraphical relations and extent of the Burdie House limestone proper; and its equivalents were to be found ranging in the same manner, beneath the mountain limestone, in the east of Fife and Stirling coal-fields, as well as, he believed, in the Lanark and Ayrshire districts. As to the vertical development of these lower coal-measures, it varied in different districts from 600 to 1800 feet, and he had measured an uninterrupted section near St. Andrews of 1400 feet, consisting chiefly of sandstones, shales, and fire-clays. Respecting the fossils of the Burdie House limestone, not a single coral, coralline, or marine shell had yet been detected in it; and so far as he was aware, nothing had yet been discovered to invalidate the opinion of Dr. Hibbert, that the limestone with its associated beds were of freshwater or estuary origin. In the lower coal-measures, however, considered as a group, he (Mr. Page) had detected

one or two instances of marine exuviæ, as in a thin band of limestone near St. Andrews, which contained fragments of minute encrinites; but, taken as a whole, the group was eminently characterized by freshwater estuary remains. The characteristic plants were *Sphenopteris affinis, bifida* and *linearis*; *Lepidophyllum intermedium*; *Pecopteris heterophyllum*; *Neuropteris Loshii*; *Calamites cannæformis*; *Lepidodendron elegans, selaginoides* and *gracilis*; *Lepidostrobus variabilis* and *ornatus*; *Stigmaria ficoides* and *stellaris*, with *Sigillaria pachyderma*, and another of more slender and regular growth. Of the animal remains the most characteristic were *Cypris faba* and *punctata*, which abounded in all the shales and limestones; *Microconchus carbonarius*; various Unionidæ, sometimes forming whole bands of limestone; *Palæoniscus Robisonii, Eurynotus*, and *Amblypterus*; *Holoptychius Hibbertii* (which was altogether different from the Holoptychius of the Old Red); *Megalichthys, Gyracanthus*, and some other well-marked ichthyolites and coprolites. So characteristic were many of these fossils, that there was little difficulty in determining by their aid the lower from the upper coal-measures. What Mr. Page chiefly wished to establish by his remarks, were,—1st. That the limestone of Burdie House was not a mere local and anomalous deposit, but had a considerable geographical range. 2nd. That its position was unmistakeably among the lower coal-measures, and beneath the mountain or marine carboniferous limestone. 3rd. That, in its palæontological features, the Burdie House limestone is of undoubted freshwater or estuary origin; and, 4th. That while the Burdie House limestone, *per se*, was of estuary origin, as most of the lower coal-measures were, yet, in several instances, bands of limestone and ironstone occurred in the series containing encrinital joints, *Retepora, Murchisonia*, and the like, thus showing that during the deposition of the lower carboniferous strata there were occasional alternations of marine and freshwater conditions.

On the Subdivisions of the Palæozoic and Metamorphic Rocks of Scotland. By D. Page.

At the former meeting Mr. Page had endeavoured to establish, that below the carboniferous limestone proper there existed in Scotland an extensive and well-defined group which he termed the "lower coal-measures," and which were evidently the equivalents of Mr. Griffith's "carboniferous slates" in Ireland. He had also endeavoured to show that the yellow sandstones of Dura Den and Stratheden were a distinct Devonian, or old red sandstone group, and clearly separable, lithologically and palæontologically, from the carboniferous system with which they were by some still confounded. He had during the past summer worked out numerous sections, both in the north and south of Scotland, and now ventured to submit the following as well-defined subdivisions of the palæozoic and metamorphic strata. He omitted all notice, in the meantime, of the Permian rocks and their supposed triassic co-relatives, believing that these groups in Scotland had, as yet, been altogether misunderstood and misinterpreted:—

Carboniferous System	Upper coal-measures. Millstone-grit (feebly indicated). Carboniferous limestone (marine). Lower coal-measures.
Old Red Sandstone System	Yellow sandstone of Stratheden and Elgin. Red sandstone and conglomerates. Caithness flags and great conglomerate. Forfar flags and tilestones.
Silurian System	Undetermined zone. Middle group of Ayrshire. Lower group of Peebles and Roxburgh.
Metamorphic Rocks	Clay-slate group. Chloritic and micaceous schist group. Hornblende schist and quartzitic group. Gneiss and granitoid schists.

Presuming that the preceding subdivisions of the carboniferous strata would now

stand uncontroverted, Mr. Page went on at length to establish his proposed groups of the lower systems. The yellow sandstones of Stratheden and Elgin, characterized by such fossil forms as *Pterichthys hydrophilus* and *Holoptychius Andersoni, Glyptolepis, Actinolepis, Stagonolepis, Telerpeton Elginense,* and *Cyclopteris Hibernicus,* were at once clearly separable from the carboniferous system above; and it is likewise readily distinguished, lithologically as well as palæontologically, from red marls, sandstones, and conglomerates which lay below. These red beds were comparatively barren of fossils, but perhaps the *Holoptychius nobilissimus, Pamphractus, Glyptopomus,* and *Phyllolepis,* were their characteristic fishes; at all events they marked the meridian of the *Holoptychius nobilissimus,* whose scales were found in every district where these red sandstones occurred. The Caithness flags, replete with such forms as *Pterichthys Milleri, Coccosteus, Dipterus, Diplopterus, Diplacanthus, Cheirolepis, Osteolopis,* and *Asterolepis,* were evidently a distinct group from the red sandstone above, and as well defined on the other hand from the Forfarshire flags and tilestones, with their *Cephalaspis, Onchus, Climatius, Parexus, Pterygotus, Kampecaris,* and other Crustaceans, as well as with their peculiar stems, seed-vessels, and undetermined flora. If the Caithness flags were not in some respects the chronological equivalents of the middle flags of Forfarshire, they certainly did not hold a lower place, and he was strongly impressed with the belief that the Forfarshire lower flags, with their curious crustaceans, fish spines, fish jaws, and seed-spores, brought the palæontologist to the same geological horizon as the Ludlow Silurians. At this stage there was yet an undetermined gap in Scottish lithology, and he was convinced that it would shortly become a question whether portions of these old red flagstones should be ranked as Upper Silurians, or the "tilestones" of Upper Silurian replaced again as the natural basis of the Devonian system. Without attempting any decided line of demarcation (and in a science like geology, where so many of its arrangements were provisional, it was better that all sharp lines of demarcation should be avoided), he was inclined to argue for the restoration of the "tilestones" to the Devonian system, as bringing the English strata more in harmony with their Scottish equivalents, and at the same time establishing for the Devonian that great basis of vertebrate life for which Sir Roderick Murchison had so long contended. Respecting the subdivision of the Silurian rocks of the south of Scotland (for in the north no certain indications of Silurian fossils had been yet detected), Mr. Page was inclined to accept the grouping suggested in the recent 'Siluria' of Sir Roderick Murchison. At all events, there could be no doubt in the mind of any one who had worked out a stratigraphical section, and this altogether independent of fossil testimony, that the greywacke grits and schists of Peeblesshire, Selkirk, and Roxburgh, were older than the Silurian limestones, flagstones, and sandstones of Ayrshire and Upper Lanark. Accepting the former as the equivalents of the Lower Silurians of England, and the latter as representing the middle beds, there were still wanting, or undiscovered, if it did exist, a set of strata corresponding to the Ludlow or Upper Silurians. Leaving this uppermost stage as undetermined in the meantime, he next proceeded, in descending order, to the metamorphic strata. It had been contended by some that it was impossible to group or separate into anything like chronological stages the metamorphic rocks; and yet those who expressed such opinions were themselves daily placing mica-schist under clay-slate, and gneiss under mica-schist. There could be no doubt, that in greatly disturbed districts, and in regions where these rocks had undergone a high degree of mineral metamorphism, it was often impossible to establish anything like order of superposition; still, by taking a sufficiently wide field, such as both slopes of the Grampians afforded, and by working out patiently many sections in detail, he thought there could be little doubt that the following was the true descending order of the metamorphic strata in Scotland:—1st. clay-slate, with and without slaty cleavage; 2nd. chloritic and micaceous schists; 3rd. quartz rock and hornblende schists, forming, perhaps, one of the best marked zones in the system; and 4th. gneiss, porphyritic gneiss, and gneissose beds, often so granitic-looking, that they were apt to be mistaken for granite, and for which he would propose the term "granitoid schists." Though chlorite slate might, in some instances, be associated with clay-slate, and mica-schists be intercalated with gneiss, still, as a general rule, the preceding order prevailed; and what was peculiar, each zone had its own limestone beds, and these so persistent in character, that he

could in most instances determine the group by an examination of the limestone quarries. In fact, as limestone strata often afforded the key to the fossiliferous groups, so limestone, in a great measure, enabled the worker out of primary formations to ascertain his lithological place and position. In submitting the preceding arrangements, he (Mr. Page) was perhaps advancing nothing new to many members of the Section; still he was aware that much doubt and error prevailed respecting the relations of the stratified system in Scotland, and by thus attempting their grouping and subdivision, it would facilitate comparison with other regions, and especially with continental Europe and North America, where so many eminent geologists were working out with admirable precision and in detail the rock arrangements of their respective localities. He had endeavoured to be as explicit as the time allowed for such an outline would permit, and would venture to predict that the time was not far distant, when the ancient rocks of Scotland, notwithstanding the obscurity of the subject and the difficulty of the research, would be as minutely grouped and as well understood, as the younger, the more attractive, and the more easily deciphered fossiliferous secondaries of England. No doubt, different geologists would attach different degrees of value to these attempted subdivisions; but in a science like geology, where as yet so much was temporary and provisional, and where the height to be ascended was so steep and arduous, the more notches in the cliff, the more easy the ascent; and if once the path were familiar and known, we could dispense with many of the intermediate notches, and make our steps the fewer and more comprehensive.

Remarks on certain Trap Dykes in Arran. By Professor Phillips, *M.A., F.R.S.*

The author exhibited maps and sections of the trap dykes between Brodich Bay and Lamlash Bay—for the purpose of showing the existence of a certain law regarding the direction of these dykes, as compared with the strata of the Red Sandstone strata, and the axes of subterranean movement in Arran. The investigation, founded on two sets of careful observations, in the years 1826 and 1855, on forty-four dykes, which were separately described for the purpose, proved the dykes to be assembled in two principal systems or groups, both included in arcs of 90°, so as to produce alternating quadrants of + and −, capable of combination into one general resultant. The dykes are not generally accompanied by vertical displacement; the sandstones on their borders are usually bleached and indurated so as to run in high crests, above the frequently excavated course of the dyke. Many special phænomena were pointed out in regard to the "Claystone," "Pitchstone," and "Greenstone" dykes, of this and other parts of Arran, as a preliminary to an excursion on the coast after the conclusion of the meeting.

Note on a recent Geological Survey of the Region between Constantinople and Broussa, in Asia Minor, in search of Coal. By H. Poole. *Communicated by* Sir R. I. Murchison, *with the permission of the* Earl of Clarendon.

Sir Roderick Murchison briefly explained, that in consequence of reports of the existence of coal on the south side of the Gulf of Nicomedia in the Sea of Marmora, he had recommended Mr. H. Poole to Her Majesty's Government as a surveyor capable of determining the nature and value of the combustible. The Earl of Clarendon had in consequence sent out that gentleman, who had ascertained that the so-called *coal* was a poor lignite only, and probably of tertiary age; and that thus the hope of the old coal of Eregli (Heraclea) being continuous to or repeated in the Gulf of Nicomedia so near to Constantinople was dispelled.

On the Geology of the District of Great and Little Ormeshead, North Wales. By John Price, *B.A.*

On the commencement and progress of the Geological Survey in Scotland. By A. C. Ramsay, *F.R.S., F.G.S.*

On some of the Geological Functions of the Winds, illustrating the Origin of Salt, &c. By Professor H. D. Rogers, *Boston, U.S.*

On the Geology of the United States. By Professor H. D. Rogers, *Boston, U.S.*

On some Reptilian Footprints from the Carboniferous Strata of Pennsylvania. By Professor H. D. Rogers, *Boston, U.S.*

Additions to the Geology of the Arctic Regions. By J. W. Salter, *F.G.*

On some Fossils from the Cambrian Rocks of the Longmynd, Shropshire. By J. W. Salter, *F.G.S., A.L.S., of the Geological Survey of Great Britain.*

The author visited the Longmynd during the summer of 1855, for the purpose of searching carefully in the sandy flag-like beds east of the principal ridge for organic remains.

The succession is as follows, in ascending order:—

1. Dark olive schists. Church Stretton, Brocards Castle, &c.
2. Harder flags and schists, with some felspathic beds.
3. Bluish fine-grained sandstones of considerable thickness and ending in a series of ripple-marked flags, as at the Carding Mill, Church Stretton; the Devil's Mouth; Winter Hill; north side of Callow Hill, Little Stretton; the Packet Stone, West of Minton.

In all these localities ripple or current marks are frequent on the surface of the stone, and in several places these are marked in such a way by radiating lines as to lead to a belief that they represent the minute drainage of the hollows as the tide receded, thus indicating littoral conditions. The large-sized conglomerates in the neighbourhood also favour the same idea.

On the surfaces of the sandy beds are many double oval impressions, not above a line long, always placed in pairs, and parallel to one another in direction, though scattered over the stone. As these twin oval indentations are not placed in any regular series, they clearly do not indicate the track of a crustacean or higher animal; and they offer on the whole the best analogy with the double holes of sand-burrowing worms, such as the Lob-worm (*Arenicola*) of our coasts. Mr. Binney of Manchester first called attention to the occurrence of such burrows on the coal sandstones of that district. The present are, however, minute in comparison. The author calls them *Arenicola didyma*. There are also many direct traces of the presence of worms in long sinuous tracts, such as are usually made by these animals.

The most interesting fossils are several specimens of the tail, and perhaps the head, of a new genus of Olenoid Trilobites, allied closely to some forms in the very lowest fossiliferous beds of America. Though imperfect, their occurrence so low down justifies the application of a distinctive name, *Palæopyge Ramsayi*.

Impressions very like those of rain-drops, and remarkable raised lines on the surfaces of the beds, are points of interest, but do not call for further notice.

These fossiliferous beds are succeeded by (4) red shales and (5) grey sandstones, another series of flaggy sandstone with ripple-marks (at the small waterfall near Church Stretton), red sandstones and grey beds alternating as far as the ridge of the Portway, beyond which, for three miles, is a great series of red sandstone with some beds of conglomerate (one bed of which is 120 feet thick). These conglomerates are chiefly of quartz rock, with much felspathic matter, and only rarely contain pebbles of syenite. They indicate the proximity of older and probably of volcanic lands.

On New Forms of Crustacea from the District of Lesmahagow. *By* R. Slimon *.

On the Shelly Deposits of the Basin of the Clyde, with proofs of change of Climate. *By* James Smith, *F.R.S., F.G.S.*

On the Structure and Mutual Relationships of the older Rocks of the Highland Border. *By* H. C. Sorby, *F.G.S.*

The author first gave a short outline of the opinions that have been entertained by various geologists respecting the origin of that structure in the metamorphic rocks, for which the term foliation has been proposed. He much objects to this, if used as though there were but one structure present in them; for, by a careful and close inspection, with or without the microscope, two, that are most distinct from one another, may very often be recognized. One of these has every character that would be the result of stratification, even in some cases including the current structures; and the other is related to it in precisely the same manner that the cleavage of slate rocks is to their bedding. This is best seen in the more micaceous bands in contorted beds of gneiss, and in them the crystalline flakes of mica often lie, not in the plane of the bands themselves, but pass on in one uniform direction, whilst the bands of varying composition bend about and are often perpendicular to the general direction of the flakes of mica. One of the most decided relations between cleavage and bedding is that cleavage lies in a plane perpendicular to the line in which pressure has acted, so as to change the dimensions of the rock. The structure just alluded to, as in some districts affecting mica-schist and gneiss, agrees with it in this; and in fact presents us with all the peculiarities that could be expected from metamorphosed cleavage, in the same manner as the other does with respect to stratification.

In some districts it appears to be absent, as is also the case with cleavage, and then only that analogous to stratification is to be seen. Metamorphic rocks are often very full of contortions, some larger and others quite small. These appear to have been formed in various manners; but may be accounted for on strictly mechanical principles. In order to explain this, the author had constructed models to represent beds that could readily and evenly give way and change their dimensions when elevated or bent, and others that would not admit of this; and by bending or elevating them, in the manner that is seen to have occurred in the case of the rocks, when composed of elastic material, no contortions are produced; whereas, in the other case, they are formed, and have precisely the same relations to the character of the elevation or bending, as those met with in the rocks themselves. The author therefore is of opinion, that nearly the whole of them may be explained on strictly physical principles, by supposing that mica-schist and gneiss were in a more or less softened condition when the movements of elevation occurred, and not in a state analogous to the unaltered rocks, that have yielded to similar actions in a very different manner; and this supposition he thinks would agree with what is indicated by other facts.

In carrying out these inquiries, some sections of the Highland border had been constructed, in which the structure described above as due to stratification was carefully distinguished from that considered to be produced by cleavage; and the result is, that there is every reason to believe that the clay-slate rocks are not more recent than the whole of the mica-schist, as has been supposed, but are older than a considerable portion of it; and on the whole are the same group of rocks prolonged to a distance beyond the limit of the metamorphic action. This supposition completely explains all the peculiarities observed; whereas, if their dip under the altered rocks was only apparent, and due to inversion, there is very good cause for concluding that the relations of the cleavage and the axes of the contortions to the general

* The tract has since been examined by Sir R. Murchison and Professor Ramsay, and is described in the Quart. Journ. Geological Society, March, 1856; the crustaceans being described by Mr. Salter.

curves of the bedding would have been very different from what may be seen by examining the rocks.

In the district about Loch Lomond the beds have been so bent by elevation that the clay-slate is newer than the metamorphic rocks in immediate contact with it. The dip of cleavage follows a uniform law in both, and shows that the elevating force there was on the north side, as is also indicated by the bedding.

On some of the Mechanical Structures of Limestones. By H. C. Sorby, *F.G.S.*

The author considers that the only satisfactory method of ascertaining the true structure of limestones, is to examine thin sections of them with the microscope. The results described in this paper were arrived at in this manner. Limestones have been usually described as more or less crystalline or earthy, but this has reference chiefly to subsequent changes, and not to their original condition. When examined with the microscope, it is seen that to describe them according to their mechanical characters would usually be far better. In this manner they may be very conveniently classed as organic sands or clays; in the same way that we may speak of felspar, sand or clay. The organic structure of the minute fragments of which they are composed is often so well preserved, that their nature and relative proportion can be satisfactorily determined.

Where they have been consolidated, the shrinking of the mass has often produced cracks and joints, afterwards filled with calcareous spar, and often presenting a beautiful appearance, when examined with the microscope, on account of their number and regularity; and showing faults of $\frac{1}{50}$th of an inch, or much less. These are totally distinct from slaty cleavage, which can be studied to great advantage in such limestones as have that structure. The author has proposed a theory to account for this, and has shown that the rocks that possess it have been so much compressed, as shown by a great variety of facts, that the position of their ultimate particles would be changed in such a manner as to give rise to precisely such a structure as that which produces cleavage. That this would be a necessary result may be proved both by calculation and experiment. In the case of limestones, it is impossible to suppose that any other than a mechanical cause can have developed the structure seen with the microscope, because the particles whose position has been changed are fragments of organic bodies, and not crystals. Besides this change of position, in many cases minute organic fragments, whose original form and structure are well known, are greatly compressed in the plane of cleavage, as shown by the change in their form and structure; and even crystals of dolomite are broken up, elongated, and their crystalline cleavage planes bent; thus showing that the rock was in a consolidated condition when the change of dimensions occurred, but that the pressure was so intense, and acted so gradually, that the whole mass of rock gave way like more malleable substances, by the movement of the particles one over another.

On the Currents produced by the action of the wind and tides, and the structures generated in the deposits formed under their influence, by which the physical geography of the Seas at various geological epochs may be ascertained. By H. C. Sorby, *F.G.S.*

The first division of this communication consisted of a description of the nature and peculiarities of the currents produced at the present period by the operation of the tides, waves, and winds, and their relations to the physical geography of the sea, in order that a proper judgment might be formed with reference to those of former epochs. It is thus seen that a knowledge of the directions and characters of the currents would furnish very much information respecting the general physical peculiarities of the seas, and the position and direction of their coasts.

The second division comprised an account of observations and experiments respecting the effects of currents on the deposits formed under their influence, by

which various structures are produced, for which the author proposes the general term "current structures." The first of these is when the beds are deposited in horizontal bands, indicating little or no current at the bottom. The second has been known by the term "ripple marking;" but a very careful study of it yields far more information than would be expected at first; for, by carefully attending to the peculiarities of its structure, the direction and velocity of the current can be very generally determined, and even the actual rate at which deposition proceeded. The third kind of structure has often been called "false bedding;" but for this the author proposes the term "drift bedding." This furnishes information respecting the direction of the current, but not necessarily the velocity. However, by carefully attending to minute facts in its structure, it appears almost certain that the actual depth of the water can in many cases be ascertained to within a fathom. By means of these various structures, the direction of the currents can be made out with great accuracy, as well as their general characters; whether they were oscillating and due to tides or stranding waves, or moved only in one direction. Thence the peculiarities in the motion of the currents from which the physical geography of the modern seas might be inferred, would permanently impress these characters on the deposits formed in them, in such a manner that similar inferences might be derived from the study of our ancient rocks.

Applying these general principles to particular cases, it was shown that the red sandstone of the valley of the Annan at Moffat was accumulated by ordinary tidal influence in a small marine loch. The detailed structure of the magnesian limestone in the south of Yorkshire proves that the tide moved in a line from S. 70° W. to N. 70° E., amongst a number of shoals. There must have been a much more open sea towards the east than the west, because the greater storm-waves come from that quarter; but yet they were never very great, as might be expected in a sea that was generally shallow and full of shoals. The Wealden also has such a structure as agrees with the rise and fall of the tide amongst a number of sand-banks, like what would occur at the mouth of a great river; and the fluvio-marine tertiaries of the Isle of Wight and Hampshire present a good example of the accumulation of deposits in a tidal estuary, whose axis ran from east by south to west by north. Many curious facts respecting the rise and fall of the tide and the currents due to the action of the prevailing west winds are seen in the old red sandstone of the central district of Scotland, and in the carboniferous strata of the north of England; and they present most determinate data for forming a conclusion with respect to the distribution of the land and sea at those periods. The carboniferous strata show that most remarkable changes must have occurred between their formation and that of the magnesian limestone; because the lines of rise and fall of the tide in those two epochs in Yorkshire are nearly perpendicular to one another. Proceeding upwards to the coal strata, to where tidal influence ceases, the author is of opinion that the currents were chiefly due to the action of the wind; for in the neighbourhood of Sheffield he finds that there is a most close agreement between their directions and that of the winds of the present period; and that their general character and arrangement agree better with this supposition than with any other that has yet occurred to him.

Stratified rocks of every period that have been thoroughly explored in this manner, lead to the conclusion that their structure not only agrees with what would take place from the action of the winds and tides, but furnish good evidence to prove that no other agent could have produced them than such as are met with in modern seas, and acting with no greater intensity than is now seen in various parts of the globe. The application of this subject also furnishes many facts of considerable interest in connexion with many other branches of theoretical geology.

The author illustrated his subject by an appropriate assortment of maps, and an ingenious machine representing the action of the waves.

On a Phyllopod Crustacean in the Upper Ludlow Rock of Ludlow. Discovered by R. Lightbody. *By the* Rev. W. S. Symonds, *F.G.S.*

This fossil is the trifid tail of a crustacean apparently allied to *Hymenocaris vermicauda* of the lower Silurians of North Wales, and was discovered by Mr.

Lightbody of Ludlow in the upper Ludlow shales on the banks of the river Tame. The addition of a new crustacean to the upper Silurian list of organic remains is an interesting fact, and the fossil was new to Mr. Salter. The various crustaceous remains lately discovered in the upper Ludlow shales and tilestones are assuming an important feature in geology, and Mr. Symonds quoted the *supposed* "Cephalaspides" in the tilestones of Kington, discovered by Mr. Banks, and expressed his doubt whether, after all, the "Cephalaspidean" plates would not turn out to be those of crustaceans. A drawing of this fossil by Mrs. H. Salwey of Ludlow has been engraved on plate for the Edinburgh New Philosophical Journal, Oct. 1855.

On the Fauna of the Lower Silurians of the South of Scotland. By Professor WYVILLE THOMSON, *F.R.S.E., Belfast.*

Exhibition of a Series of Preparations obtained from the Decomposition of Cannel Coal and the Torbane Hill Coal. By Dr. TRYFE.

On the Probable Maximum Depth of the Ocean. By SEARLES V. WOOD, *Jun.*

The author, after pointing out that if a surface be rugose in such a manner that for every elevation upon it there exists an equal depression, and that if the interstices be then filled in with liquid, it would be found, that when the area left uncovered equalled the area covered by the liquid, the height of the prominences above the liquid level would equal the depth of the depressions beneath the same level, and that when such areas were as 2 to 1, or 3 to 1, the heights and depths would be in those ratios, and so on in direct proportion,—suggested that if it were assumed that the earth's surface if uncovered would exhibit such a rugosity as above, then, since the ocean area is to the land area as 3 to 1 (nearly), it would be found over large spaces of a depth three times the average height of any mountain mass; and that if the average height of the mountain mass of the Himaleh were taken at from 13,000 to 14,000 feet, a large space of the ocean would give soundings of from 39,000 to 42,000 feet (eight miles), being three times that height.

BOTANY AND ZOOLOGY INCLUDING PHYSIOLOGY.

BOTANY.

An attempt to classify the Flowering Plants and Ferns of Great Britain according to their geognostic relations. By* JOHN G. BAKER.

I. *Fundamental Generalities.*—1. In regulating the distribution of species, and modifying specific types, the subjacent geological formations, principally by reason of their mechanical properties, exercise an influence, which, taken as a whole, is secondary only to that of climate, which it modifies, and by which it is modified perpetually.

2. With reference to the facility with which they yield to disintegration and to their hygroscopicity and porosity, strata are essentially separable into two principal classes, *dysgeogenous* and *eugeogenous.*

3. *Dysgeogenous* formations are those which are disintegrated with difficulty and yield only a feeble detritus. On a grand scale they absorb moisture readily, and furnish stations characterized by their comparative dryness. Rocks of this class mostly contain a large proportion of carbonate of lime in their composition.

4. *Eugeogenous* formations are those which abrade easily and yield an abundant

* This paper, with a complete catalogue, &c., has been issued in the form of a pamphlet, and may be procured of the author, Thirsk, Yorkshire, or of the publishers, W. and F. G. Cash, London.

superficial detritus, which may be either of a sandy or clayey nature. They are comparatively impermeable, and consequently hygroscopic upon a grand scale, furnishing damper stations than the rocks of the opposite category, especially when the detritus is clayey.

5. Every species possesses essentially its characteristic special range of lithological adaptability, in the same way that each possesses its characteristic special range of climatic adaptability. Under equal climatic conditions some species are restricted to more or less distinctly marked dysgeogenous situations, and others to more or less distinctly marked eugeogenous situations; but a greater number can adapt themselves more or less decidedly to stations of either class.

6. In proportion as we advance from an austral to a boreal, and from a continental to an insular climate, the proportion in number which the *restricted* (*i. e.* dysgeogenous and eugeogenous) bear to the *ubiquitous* species lessens, principally through reason of many of the eugeogenous species being able, under more humid conditions of climate, to adapt themselves also to dysgeogenous situations.

II. *The Field of Study lithologically viewed.*—For phytostatic purposes the surface of Britain may be conveniently considered as subdivided into six lithological zones, viz.—1. *Psammo-eugeogenous*; including the endogenous and metamorphic rocks of the Scotch Highlands and sedimentary strata that surrounds them.

2. *Mixed*: including the Silurian and Devonian, and accompanying strata of the southern part of Scotland and of Wales and the West of England.

3. *Primary dysgeogenous*: including the carboniferous formations of the Penine chain and Permian limestones, enclosing the coal-fields of Durham and West Yorkshire.

4. *Eugeogenous*: including the New Red Sandstone strata of the centre of England.

5. *Secondary dysgeogenous*: including the liassic, oolitic, Wealden and cretaceous strata of the south-eastern half of England.

6. *Subeugeogenous*: including the fen country and London and Hampshire tertiary basins. These are almost all occasionally interrupted by intervals of less typical or exceptional nature.

III. *Summary of Species.*—

Class.		No. of Species.	Per-centage.
A.	Dysgeogenous	92	7+
AB.	Subdysgeogenous	75	6−
B.	Ubiquitous	699	53+
CB.	Subeugeogenous	89	7−
C1.	Eugeogenous, austral	65	5−
C2.	,, boreal	79	6+
D.	Maritime	90	7−
E.	Hibernian and Sarnian	37	3−
F.	Local or dubious	89	7−
		1315	

On Galium montanum, *Thuill. and* G. commutatum, *Jord.* *By* John G. Baker.

The author announced the discovery in Yorkshire of these two continental species, and pointed out their distinctive characters.

Exhibition of a Series of Specimens illustrating the Distribution of Plants in Great Britain, and Remarks on the Flora of Scotland. By Professor Balfour, *M.D., F.R.S.E.*

After making some general remarks on the geographical distribution of plants, and calling attention to the important addition made by Drs. Hooker and Thomson, Mr. Spruce and other botanical travellers, Dr. Balfour proceeded to the consideration of the British Flora. He noticed the important services rendered by Mr. Watson, and illustrated the flora of the British Isles by means of specimens arranged on large sheets of paper in a map-like manner, so as at once to suggest the prevalent forms of plants in different districts.

He particularly referred to Forbes' five floras. 1. Flora of West of Ireland. 2. Flora of South-west of England and South-east of Ireland. 3. Flora of South-east of England. 4. Alpine flora. 5. Germanic flora.

He then drew particular attention to the alpine flora as developed on the Scotch mountains, and gave the results of a trip to Ben Lawers in August 1855. During the trip, abundance of *Cystopteris montana* was gathered on Ben Lawers as well as on Corrach Uachdar; *Pseudathyrium alpestre* had been collected on Ben Lawers, Craig Chailleach, Meal Ghyrdy, and Corrach Uachdar. *Pseudathyrium flexile* had been seen sparingly on Ben Lawers.

Remarks on the Trunk of a Tree discovered erect as it grew, within the Arctic Circle, in 75° 32′ N., 92° W., or immediately to the Northward of the Narrow Strait which opens into the Wellington Sound. By Captain Sir E. Belcher, *R.N., F.R.A.S.*

Having despatched several shooting parties in quest of hares and ptarmigan, one commanded by the boatswain returned about midnight, on the 12th of September, 1853, bringing a report that they had discovered the heel of the topgallant-mast of a ship in an erect position, about one mile and a half inland; and the carpenter's mate, one of the party, asserting that it was certainly "a worked spar," of about eight inches diameter, seemed to confirm this report. Such a communication, from such authorities, and considered of sufficient importance to awake me, startled me not a little. One point, however, was not so clear to my imagination,—it was too far inland; and, moreover, in a hollow. On the morrow I proceeded, accompanied by the boatswain, armed with picks and crows, to search for and bring in this discovery. But it was not without great difficulty that it was re-discovered, snow having nearly obliterated the foot-marks of the previous day. I at once perceived that it was not a mast, nor a worked spar; nor placed there by human agency. It was the trunk of a tree, that had probably grown there, and flourished, but at what date who would venture to determine? At the period when whales were thrown up and deposited, as we found them, at elevations of 500 to 800 feet above the present level of the sea, and the land generally convulsed, and also when a much higher temperature prevailed in these regions, this tree probably put forth its leaves, and afforded shade from the sun. Such a change of climate just then would have been peculiarly acceptable! I directed the party which attended me to proceed at once to clear away the soil, then frozen mud, and splintering at every effort like glass. The stump was at length extracted, but not without being compelled eventually to divide the tap root; and collecting together the portions of soil which were immediately in contact, and surrounding the tree, in the hope of discovering impressions of leaves or cones, the whole was carefully packed in canvas, and eventually reached this country. Near to the spot in question I noticed several peculiar knolls, from which I was led to infer that other trees had grown there; and I caused them to be dug into. But they proved to be peat mosses, about nine inches in depth, and on closer examination, in my cabin, proved to contain the bones of the Lemming, in such extraordinary quantity, as to constitute almost a mass of bony manure. Through the kindness of Dr. Hooker, the entire matter having been forwarded to Sir W. Hooker at Kew, I am enabled to furnish the following interesting remarks: "The piece of wood brought by Sir Edward Belcher from the shores of Wellington Channel belongs to a species of pine—probably to the *Pinus* (*Abies*) *alba*, the most northern conifer. This, the 'white spruce,' advances as far north as the 68th parallel, and must be often floated down the great rivers of North America to the Polar Ocean. The structure of the wood of the specimen brought home, differs remarkably in its anatomical characters from that of any other conifer with which I am acquainted. Each concentric ring (or annual growth) consists of two zones of tissue; one, the outer, that towards the circumference, is broader, of a pale colour, and consists of ordinary tubes of fibres of wood marked with discs common to all Coniferæ. These discs are usually opposite one another when more than one row of them occur in the direction of the length of the fibre; and, what is very unusual, present radiating lines from the central depression to the circumference. Secondly, the inner zone of each annual ring of wood is narrower, of a dark colour, and formed of more slender woody fibres, with thicker walls in proportion to their diameter.

These tubes have few or no discs upon them, but are covered with spiral striæ, giving the appearance of each tube being formed of a twisted band. The above characters prevail in all parts of the wood, but are slightly modified in different rings. Thus, the outer zone is broader in some than in others, the disc-bearing fibres of the outer zone are sometimes faintly marked with spiral striæ, and the spirally marked fibres of the inner zone sometimes bear discs. These appearances suggest the annual recurrence of some special cause that shall thus modify the first and last-formed fibres of each year's deposit, so that that first formed may differ in amount as well as in kind from that last formed; and the peculiar conditions of an arctic climate appear to afford an adequate solution. The inner, or first formed zone, must be regarded as imperfectly developed, being deposited at a season when the functions of the plant are very intermittently exercised, and when a few short hours of hot sunshine are daily succeeded by many of extreme cold. As the season advances, the sun's heat and light are continuous during the greater part of the twenty-four hours, and the newly-formed wood fibres are hence more perfectly developed; they are much larger, present no signs of striæ, but are studded with discs of a more highly organized structure than are usual in the natural order to which this tree belongs."

On the Flowering of Victoria Regia, *in the Royal Botanic Garden, Glasgow. By* P. Clark, *Curator of the Garden.*

The author traced in the first place the history of the cultivation of this plant in Britain, and then explained the method employed in the Botanic Garden of Glasgow, which was opened to the Members of the Association.

The structure in which the water-lily is grown was specially erected for the purpose, and contains a tank 20 by 22 feet, so constructed as to give a depth of 3 feet, gently sloping to half that depth at the edges. In the centre of the tank there is a square pit one foot in depth, over which is formed a conical mound, consisting of about three cart-loads of charred loam, leaf-mould, &c. In this the *Victoria* was planted on the 12th of May last. The temperature of the water kept up during the whole summer has been from about 83° to 85° Fahr. When planted, the largest leaf was not more than 12 inches in diameter, but the size and number of leaves soon increased, and towards the end of the month some of them were a foot and a half in diameter. The increase continued; on the 15th of June one leaf measured 2 feet in diameter; but after this date, in consequence of much dull rainy weather, the plant did not make progress until towards the end of July, when it again started into healthy growth and rapidly gained strength, so much so, that, in the course of a week, it had gained fourteen good leaves, some of them measuring 3 feet 6 inches in diameter. By the 15th of August the plant had increased to great size, and presented a remarkably beautiful and healthy appearance; at this time some of the young leaves increased in diameter at the rate of 12 or 14 inches in twenty-four hours. On the 22nd of August a flower-bud was discovered, the plant being then very healthy and vigorous, and the largest leaf 4 feet 10 inches across. On the morning of the 31st of August, the flower-bud was seen to move itself as far as possible in one direction, then back again in a semicircle, finally raising itself into a somewhat erect position out of the water, so as to rest against the margin of the young leaf from the axil of which it was produced. As the day advanced the flower began to open, diffusing a fragrance like that of a well-ripened pine-apple through the house, which was also distinctly perceptible in the adjoining palm-house. At 3 o'clock a number of the petals opened, and at 5 P.M. the flower expanded to considerable size, continuing to increase throughout the evening and night. At 10 o'clock on the following morning (1st Sept.) the petals began to close again, and in little more than an hour it was almost quite closed, in which state it remained during the forenoon. In the afternoon (between 2 and 3 o'clock) it again opened, and more fully than before, the central petals rising up in a beautiful manner; the full expansion occurred at half-past 6 P.M. The flower, when in its best condition, was examined by 2000 visitors during the afternoon. It measured 13 inches in diameter; but one produced since then was half an inch larger. One leaf measured 5 feet 2 inches in diameter, the margin being turned up in the tray form so peculiar to the leaf of this plant.

The other flowers subsequently produced have gone through the same stages as the one now described; in all six flowers have been produced, and two buds are now nearly ready to expand—one of which will probably be in full blow to-morrow (Tuesday), and will be followed by others during the present week.

The first cultivators of the plant in England believed that it required a great amount of light; but the success which has attended it in the Crystal Palace at Sydenham has shown that it is capable of very successful cultivation even where shaded by palms and at a great distance from the glass. This circumstance has led to the belief that shading is in fact desirable; but I have hitherto treated the plant in such a manner as to secure as much light as possible, and have no reason to complain of the result.

The growth of confervaceous plants proves detrimental to the *Victoria*, and care has been taken throughout to keep down such weeds.

In the same tank with the *Victoria* there are a few aquatic plants, such as the *Pontederia crassipes, Pistia stratiotes*, and *Nymphæa Devoniensis, N. dentata, N. cærulea*, and other kinds.

On the Influence of Light on the Germination of Plants. By Dr. DAUBENY.

On the Hancornia speciosa, *Artificial Gutta Percha and India Rubber. By the* Chevalier DE CLAUSSEN.

In the course of my travels as botanist in South America, I had occasion to examine the different trees which produce the india-rubber, and of which the *Hancornia speciosa* is one. It grows on the high plateaux of South America, between the tenth and twentieth degrees of latitude south, at a height from three to five thousand feet above the level of the sea. It is of the family of the Sapotaceæ, the same to which belongs the tree which produces gutta percha. It bears a fruit, in form not unlike a bergamot pear, and full of a milky juice, which is liquid india-rubber. To be eatable, this fruit must be kept two or three weeks after being gathered, in which time all the india-rubber disappears or is converted into sugar, and is then in taste one of the most delicious fruits known, and regarded by the Brazilians (who call it Mangava) as superior to all other fruits of their country. The change of india-rubber into sugar led me to suppose that gutta percha, india-rubber, and similar compounds contained starch. I have therefore tried to mix it with resinous or oily substances, in combination with tannin, and have succeeded in making compounds which can be mixed in all proportions with gutta percha or india-rubber without altering their characters. By the foregoing it will be understood that a great number of compounds of the gutta percha and india-rubber class may be formed by mixing starch, gluten, or flour with tannin and resinous or oily substances. By mixing some of these compounds with gutta percha or india-rubber, I can so increase its hardness, that it will be like horn, and may be used as shields to protect the soldiers from the effect of the Minie balls; and I have also no doubt that some of these compounds, in combination with iron, may be useful in floating batteries and many other purposes, such as the covering the electric telegraph wires, imitation of wood, ship-building, &c.

On the Employment of Algæ and other Plants in the Manufacture of Soaps. By the Chevalier DE CLAUSSEN.

When I was experimenting on several plants for the purpose of discovering fibres for paper pulp, I accidentally treated some common sea-weeds with alkalies, and found they were entirely dissolved, and formed a soapy compound which could be employed in the manufacture of soap. The making of soaps directly from sea-weeds must be more advantageous than burning them for the purpose of making kelp, because the fucus oil and glutinous matter they contain are saved and converted into soap. The Brazilians use a malvaceous plant (Sida) for washing instead of soap, and the Chinese use flour of beans in the scouring of their silk; and I have found that not only sea-weed, but also many other glutinous plants, and gluten and flour, may be used in the manufacture of soap with advantage.

On Papyrus, Bonapartea, *and other Plants which can furnish Fibre for Paper Pulp. By* Chevalier De Claussen.

The paper-makers are in want of a material to replace rags in the manufacture of paper, and I have therefore turned my attention to this subject, the result of which I will communicate to the Association. To make this matter more comprehensible, I will explain what the paper-makers want. They require a cheap material, with a strong fibre, easily bleac! ed, and of which an unlimited supply may be obtained. I will now enumerate a few of the different substances which I have examined for the purpose of discovering a proper substitute for rags. Rags containing about 50 per cent. of vegetable fibre mixed with wool or silk are regarded by the paper-makers as useless to them, and several thousand tons are yearly burned in the manufacture of prussiate of potash. By a simple process, which consists in boiling these rags in caustic alkali, the animal fibre is dissolved, and the vegetable fibre is available for the manufacture of white paper pulp. Surat, or Jute, the inner bark of *Corchorus indicus*, produces a paper pulp of inferior quality bleached with difficulty. Agave, *Phormium tenax*, and Banana or plantain fibre (Manilla hemp), are not only expensive, but it is nearly impossible to bleach them. The Banana leaves contain 40 per cent. of fibre. Flax would be suitable to replace rags in paper manufacture, but the high price and scarcity of it, caused partly by the war, and partly by the injudicious way in which it is cultivated, prevents that. Six tons of flax straw are required to produce one ton of flax fibre, and by the present mode of treatment all the woody part is lost. By my process the bulk of the flax straw is lessened by partial cleaning before retting, whereby about 50 to 60 per cent. of shoves (a most valuable cattle food) are saved, and the cost of the fibre reduced. By the foregoing it will be seen that the flax plant only produces from 12 to 15 per cent. of paper pulp. All that I have said about flax is applicable to hemp, which produces 25 per cent. of paper pulp. Nettles produce 25 per cent. of a very beautiful and easily bleached fibre. Palm-leaves contain 30 to 40 per cent. fibre, but are not easily bleached. The Bromeliaceæ contain from 25 to 40 per cent. fibre. *Bonapartea juncoidea* contains 35 per cent. of the most beautiful vegetable fibre known; it could not only be used for paper pulp, but for all kinds of manufactures in which flax, cotton, silk, or wool are employed. It appears that this plant exists in large quantities in Australia, and it is most desirable that some of our large manufacturers should import a quantity of it. The plant wants no other preparation than cutting, drying, and compressing like hay. The bleaching and finishing it may be done here. Ferns give 20 to 25 per cent. fibre, not easily bleached. Equisetum, from 15 to 20 per cent. inferior fibre, is easily bleached. The inner bark of the lime-tree (*Tilia*), gives a fibre easily bleached, but not very strong. Althea and many Malvaceæ produce from 15 to 20 per cent. paper pulp. Stalks of beans, peas, hops, buckwheat, potatoes, heather, broom, and many other plants contain from 10 to 20 per cent. of fibre, but their extraction and bleaching present difficulties which will probably prevent their use. The straws of the Cereales cannot be converted into white paper pulp after they have ripened the grain; the joints or knots in the stalks are then so hardened that they will resist all bleaching agents. To produce paper pulp from them they must be cut green before the grain appears, and this would probably not be advantageous. Many grasses contain from 30 to 50 per cent. of fibre, not very strong, but easily bleached. Of indigenous grasses, the Rye-grass contains 35 per cent. of paper pulp, the *Phalaris* 30 per cent., *Arrenatherum* 30 per cent., *Dactylis* 30 per cent., and *Carex* 30 per cent. Several reeds and canes contain from 30 to 50 per cent. of fibre, easily bleached. The stalk of the sugar-cane gives 40 per cent. of white paper pulp. The wood of the Coniferæ gives a fibre suitable for paper pulp. I made this discovery accidentally in 1851, when I was making flax cotton in my model establishment at Stepney, near London. I remarked that the pine wood vats in which I bleached were rapidly decomposed on the surface into a kind of paper pulp; I collected some of it, and exhibited it in the Great Exhibition, but as at that time there was no want of paper material, no attention was paid to it. The leaves and top branches of Scotch fir produce 25 per cent. of paper pulp. The shavings and sawdust of wood from Scotch fir gives 40 per cent. pulp. The cost of reducing to pulp and bleaching pine wood will be about three times that of bleaching rags. As none of the above-named substances or plants would

entirely satisfy on all points the wants of the paper-makers, I continued my researches, and at last remembered the *Papyrus* (the plant of which the ancients made their paper), which I examined, and found to contain about 40 per cent. of strong fibre, excellent for paper, and very easily bleached. The only point which was not entirely satisfactory was relative to the abundant supply of it, as this plant is only found in Egypt. I directed, therefore, my attention to plants growing in this country; and I found to my great satisfaction that the common rushes (*Juncus effusus* and others) contain 40 per cent. of fibre, quite equal, if not superior, to the *Papyrus* fibre, and a perfect substitute for rags in the manufacture of paper, and that one ton of rushes contains more fibre than two tons of flax straw.

Remarks on the Effects of Last Winter upon Vegetation at Aberdeen. *By* Professor Dickie, *M.D.*

The lowest temperature was recorded on the 15th of February, viz. minus 1° of Fahrenheit's thermometer, the mean temperature of the entire month having been 26°·8 Fahr. The effect of such severe frost was very considerable on many plants which for several years previously had been in a thriving condition, and were supposed to be sufficiently hardy to entitle them to a place among species fitted for the garden or the forest. Rhododendrons were more or less injured, and many of them destroyed down to the point where they were protected by the snow, which had fallen copiously. Budded roses were, generally speaking, destroyed, the stock being uninjured. Even the Ayrshire rose (a variety of *Rosa arvensis*) was generally killed to the ground. Common roses and cabbage roses were uninjured. Several interesting and valuable species of pine were either severely injured or killed to the ground, as *Pinus Russeliana, P. macrocarpa, P. insignis, P. Teocote,* and *P. longifolia.* Plants of *Araucaria imbricata,* which had resisted the influence of previous winters, were killed to the ground. Generally speaking, all of this species unprotected by snow were destroyed. Species of *Taxodium, Cupressus, Fitzroya, Saxegothea,* and *Cephalotaxus* were injured or killed to the ground. Even large plants of the Irish yew were destroyed down to the part protected by snow. The common and Portugal laurels, the holly, and others, were more or less injured, and in some cases the growth of ten or more years destroyed. Among wild plants the influence of the low temperature was most obvious upon whin and broom, which in exposed places were killed down to the part covered by snow, and in not a few instances as far as the ground.

Respecting the exotic trees and shrubs reported as either materially injured or totally destroyed, it would be rash to infer that this indicates their inability to resist low temperatures under any circumstances. In every instance it was observed that the destruction was greater in low than in high localities, and this even in the same garden. In one garden, a low sheltered spot, the great destruction occasioned by the frost of February was attributed by the proprietor to the fact that there was continued growth till January, the sudden transition to a low temperature causing the destruction of parts not properly matured.

The effects of last winter in different parts of the United Kingdom has demonstrated that a temperature approaching zero of Fahrenheit occasions almost irreparable damage to many introduced species; and that even some indigenous plants, as the whin and broom, are liable to periodical destruction of all the part above the soil. Such facts also enable us better to appreciate that admirable arrangement by which most of our native perennial species are able to survive the most inclement season. The subterranean stock is protected by the snow which accumulates in severe winters and the soil in which it is imbedded; the reviving influence of spring stimulating the upward development of the subterranean buds and the formation of leaves, flowers, and seed. It appears unnecessary to urge at any length the importance of recording the influence of different seasons upon exotics as well as on our native species.

Much has been done of late years to increase the number of foreign plants likely to bear free exposure in our climate. The experience of last winter has shown that too sanguine expectations have been formed regarding some, and that our collections are liable to periodical thinning occasioned by the influence of low temperatures on species which are more delicate than had been supposed. The loss of time and of

capital occasioned by such occurrences render these inquiries more than subjects of interest to the physiologist merely. Every garden in the kingdom, whether public or private, ought to be considered as an experimental establishment; the subjects of experiment are already provided, viz. the trees and shrubs which have been introduced, and the varying seasons are the agents whose influence we ought to observe and record.

A continued series of such observations would ultimately lead to important results, and we should cease to hear of valuable soil encumbered by plants which must ultimately succumb under the influence of unusually severe winters. It is the interest of all parties to give aid in collecting the kind of information to which we have been referring; and in our gardens and our forests we cannot fail ultimately to reap important results from the accumulation of such practical knowledge.

On Impregnation in Phanerogamous Plants. By Dr. DUNCAN.

1. Description of the development of the ovules of *Tigridia conchiflora*.

2. Experiments upon the duration of the process of the passage of the pollen-tube down the style.

The rate of growth determined.

The pollen-tube asserted to be cellular and to be nourished in its passage by the cells of the female plant contiguous to it.

3. The independence of the pollen-tube both in its powers of growth and impregnation of the pollen grain proved by experiments of series 2.

4. The pollen-tube abuts against the embryo-sac, but does not perforate; the wall of the embryo-sac is cellular, the contents are granular.

5. The embryo-sac is pushed back, and the end of the pollen-tube swells out before losing its contents.

6. Cells do not appear in the impregnated embryo-sac for some days. A mingling of the granular contents of the last cell of the pollen-tube with the granular contents of the embryo-sac first occurs.

7. The cells of the coat of the embryo-sac have been usually mistaken for "germ-cells."

Exhibition of a Collection of Ferns from Portugal. By C. H. FURLONG.

These plants were prepared and dried by Mr. Pike, Consul for the United States at Oporto, and were remarkable for the careful manner in which they had been mounted.

On the Flowers and Vegetation of the Crimea. By Dr. MICHELSON.

The author confirmed what is known of the plants of this at present deeply interesting part of the world. The vegetation is generally sub-tropical, and in the valleys and sides of the hills most prolific. At present only a small part of it is cultivated, but it is susceptible of the highest culture, and of supporting a dense population.

ZOOLOGY.

Notes on the Brachiopoda observed in a Dredging Tour with Mr. M'ANDREW *on the Coast of Norway, in the Summer of the present year,* 1855. *By* LUCAS BARRETT, *F.G.S.*

In the course of our cruise we met with four species of living Brachiopoda, belonging to three out of the five recent families of those shells. Fresh specimens of one or more of them were obtained almost daily for six weeks; and as during a month of that time we were north of the Arctic circle, enjoying perpetual sunlight, the opportunity of watching their movements was extremely favourable.

1. *Terebratulina caput-serpentis.* This species, which shows more of itself than any, and protrudes its cirri further, was met with everywhere in small numbers from 30 to 100 fathoms, often attached to *Oculina.* The cirri on the reflected part of the arms were shorter than those on the first part, were almost constantly in motion, and were often observed to convey small particles to the channel at their base. When placed in a small glass of sea water the valves gradually opened. Individuals remaining attached to other objects manifested a remarkable power and disposition to move on their pedicles. Detached specimens could be moved about without causing the animal to close its valves. If any part of the protruded cirri were touched, they were retracted and the shell closed with a snap, but soon opened again. When the oral arms are retracted, the cirri are bent up, but are gradually uncoiled and straightened when the shell is opened, before which the animal has been often observed to protrude a few of its cirri, and move them about as if to ascertain if any danger threatened. Only on one occasion a current was observed to set in on one side between the two rows of cirri. I had been attempting to ascertain the existence of currents, by introducing small quantities of indigo into the water near the animal with a camel's-hair brush; three times the water was forcibly drawn in, and the particles of indigo were seen to glide along the groove at the base of the cirri in the direction of the mouth.

2. *Waldheimia cranium* occurred on several occasions between Vigten Islands and the North Cape, in 25 to 160 fathoms, attached to stones; only abundant at Omnæsöe. It does not protrude its cirri behind the margin of the shell. No currents were detected, though frequently sought for. This species belongs to the division of Terebratulidæ with a long loop, in which the oral arms are so fixed to the calcareous skeleton as to be incapable of motion, except at their spiral terminations. It was moderately abundant in the extreme north from Tromsöe to the North Cape in 70 to 150 fathoms of water. It has been supposed that these conjoined spiral ends can be unrolled like the proboscis of a butterfly: I never saw any disposition of the kind manifested. This species is more lively than *caput-serpentis,* moving often on its pedicle, and is also more easily alarmed.

3. *Rhynchonella psittacea* was moderately abundant in the extreme north, from Tromsöe to the North Cape, in a living state, in 40 to 150 fathoms; dead valves were found at Hammerfest in mud. I found the *Rhynchonella* very difficult to examine, the animal being extremely timid, and closing its valves directly when disturbed. The coiled arms are extended, so that the cirri when unbent come as far as the margin of the shell. I have frequently seen this species open, but it never protruded its arms.

4. *Crania anomala,* Mull. sp., was only met with from Drontheim to Tromsöen, in 25 to 100 fathoms water. The cirri of *Crania* are protruded beyond the margin of its valves, but the arms are not extended. The shell opens by moving upon the straight side as on a hinge, without sliding the valve.

On the Occurrence of the Pentacrinoid Larva of Comatula rosacea, *in Lamlash Bay, Isle of Arran. By* Professor CARPENTER, *M.D., F.R.S.*

After giving a general history of the discovery of the so-called *Pentacrinus Europæus* by Mr. J. V. Thompson, of Cork, in 1823, of his subsequent identification of it as the attached larva of *Comatula,* and of the confirmation of this identification by Prof. E. Forbes, Mr. W. Thompson (of Belfast), and Dr. R. Ball (of Dublin), Dr. Carpenter stated that he had recently succeeded in dredging it up, in all stages of growth, in Lamlash Bay, where it occurred in great abundance, attached to the fronds of the common *Laminaria.* He expressed the hope of being able hereafter to give a complete history of its development; as he was about again to proceed to Lamlash Bay with Prof. Kölliker, for the purpose of making further investigations on the subject.

On the Structure and Development of Orbitolites complanatus. *By* Professor CARPENTER, *M.D., F.R.S.*

In this communication, the author gave a general account of his researches on *Orbitolites* full details of which will be found in the Philosophical Transactions for

1856; his special object being to show the very wide range of variation that presents itself in this type, within the limits of a single species, in illustration of his evening discourse on the general question, "What is a species?"

Description of a New Species of Trematode Worm (Fasciola gigantica). *By* T. Spencer Cobbold, *M.D., Assistant Conservator of the Anatomical Museum, University of Edinburgh.*

In respect to this Entozoon, Dr. Cobbold observed as follows:—"The trematode now before the Association, designated *Fasciola gigantica*, varies in length from an inch and a half to nearly three inches, most of the specimens being about two inches; their breadth averages three lines, some attaining the third of an inch. The general form of the body is elongated, and rounded at the caudal extremity, in which latter feature it differs very markedly from *F. hepatica*. The larger or more fully developed individuals present slight irregularities or crenations of the lateral margins near the neck; a character, however, by no means constant. The borders are more attenuated than in the common species, and the substance of the body is thinner. The anterior extremity is prolonged forward about two lines, and terminates in a sucker half a line in diameter. There is no evident distinction between what has been termed head and neck, but the part to which the latter title is assigned is very prominent on the dorsal surface, from the distended condition of the oviducts and seminal reservoir lying immediately beneath.

"The digestive apparatus commences by a short œsophagus proceeding downward from the base of the oval sucker; while in the neck it divides into two slightly diverging trunks which pass on either side of the ventral sucker, again approximate, and are continued to the tail. On their passage down, the two principal trunks lie almost parallel, near the mesial line of the body; they give off eight or ten secondary branches, which proceed to the lateral margins, and end in blind cæca; small twigs also proceed from the main tubes inwards, but they do not extend beyond the middle line, and present very few subdivisions. The ramifying systems of digestive cæca in each lateral segment of the animal are not absolutely symmetrical, neither is there uniformity in respect of number; they preserve, however, a general resemblance both in the degree of subdivision and in the direction which the secondary trunks assume. The downward direction of the branches, and the angle of divergence resulting from such a disposition of parts, form a striking contrast to the arrangement of that system of canals situated nearer the dorsal aspect of the body, and usually regarded as the circulatory apparatus. These vessels are represented in *F. gigantica* by a single median trunk, from which numerous primary branches pass obliquely upward to the sides.

"We may here remark, that considerable dispute has arisen among helminthologists, as to the propriety of regarding this series of canals as vascular; some have even expressed doubts as to the presence of any true organs of circulation in the trematode worms, and the distinguished authority Van Beneden holds this opinion. Those who regard the superficial set of tubes in the light of an excretory or secreting gland, ground their view on the circumstance of a supposed caudal opening, through which matters thrown into the median vessel frequently pass. M. Blanchard has shown the aperture in question to result from over-distension of the canal, which readily gives way at this, its weakest point; our own attempts to inject have confirmed this observation.

"Accepting M. Blanchard's explanation as correct, we have to state further, in regard to these vessels, that they exhibit less regularity of distribution than obtains in the branching tubes of the alimentary system, and they inosculate freely from one end of the body to the other. Irrespective of these distinguishing marks, there is a disparity of calibre between the two sets of tubes, and all their peculiarities taken together strongly convince us of their true vascular nature.

"The external spiral appendages, with minute orifices of the reproductive organs, occupy the same relative position as in *F. hepatica*, i. e. lying directly in front of the second or great ventral sucker. In reference to these structures—the nervous system and other special parts—it is unnecessary to give additional particulars; their characters resembling in all respects those seen in the typical species, and which are now so fully understood.

"*Fasciola gigantica*, Cobbold.—Corpore compresso, elliptico-lanceolato, terunciatim longo, antrorsum attenuato; ore hausterioque antice; collo elongato, cylindrico; caudâ rotundatâ; ventriculo dendritico, ramis clausis.

Habitat in hepate *Camelopardalis Giraffæ.*"

Description of a malformed Trout. By T. SPENCER COBBOLD, *M.D. &c.*

The author of this communication remarked as follows:—"For the specimen now before the Association I am indebted to Mr. Thomas Turnbull, who captured it while fly-fishing in the river Jed, near Jedburgh. He stated, that though for many years familiar with different kinds of trout, he had never met with one of this form. Its chief peculiarity, viewed externally, consists in the preponderant depth of the body, as compared with the length, giving the animal a hump-backed appearance, and causing it in outline to resemble individuals of the Sparidæ or Cyprinidæ, rather than members of its own group. To ascertain the cause of this anomaly, we proceeded to examine the viscera, under the impression that any deviation from the structural arrangement usually observed in Salmonidæ would indicate a hybrid, the visceral morphology at the same time suggesting the kind of fish whence such agency had been derived.

"Turning down the integument, and dissecting the great lateral muscular mass from one side so as to expose some of the ribs and diverging appendages, these parts, and some of the vertebral segments which had also been laid bare, at once offered an explanation of the longitudinal shortening of the trunk; we had here, in fact, an extreme abrogation of the spinal column, resulting from the coalescence of numerous vertebral 'centra,' giving rise secondarily to modifications in the surrounding soft parts.

"The following is a brief record of the skeletal peculiarities:—

"The vertebral segments, not including the bony elements of the head, which appear natural, are fifty-six in number. The first seven, proceeding from before backward, have their bodies or 'centra' united into one bone, the multiple parts of which are recognized by grooves at the side, and further indicated by seven corresponding spinous processes above, and as many ribs, with the accompanying styliform appendages, below. A single 'centrum' carries the neural and hæmal elements of the eighth and ninth vertebræ.

"Thus far the bones do not present any marked change of position, save that which immediately results from their close approximation. There is a little bending forward of the tips of the spinous processes belonging to the five hindmost, but throughout their greater extent they take, as usual, an oblique course backward.

"The tenth vertebral quantity is normal, but its neural spine, to which is articulated the first of the interspinous bones, is much curved forward. The eleventh and twelfth are conjoined; their laminæ or 'neurapophyses' slope backward, as in the healthily-developed trout, but the corresponding neural spines have a perpendicular direction. The thirteenth segment is quantitatively natural, its autogenous parts having a similar disposition to the foregoing. The bodies of the fourteenth and fifteenth vertebræ are united to form a single 'centrum.' The sixteenth and seventeenth are likewise anchylosed, but more attenuated. The 'centra' of the succeeding five segments, viz. the eighteenth, nineteenth, twentieth, twenty-first, and twenty-second, are all developed into a single osseous mass. The neural spines of these, and the preceding six, are all very closely packed together; they support the eleven interspinous bones, and in consequence of a vertical position, have tilted up the latter with their associated fin rays, so as to produce the great dorsal elevation. The ribs curve obliquely forward, and this mal-direction, especially at the upper part of the hæmal arches, applies more or less to all the 'pleurapophysial' elements of the spinal series at present described; the small osseous appendages agree in number and relation.

"From the twenty-third to the thirty-third vertebra inclusive, the neural and hæmal 'apophyses' are attached to a single bone, which is consequently the representative of eleven 'centra.' The laminæ or 'neurapophyses' of the first six segments are directed diagonally forward, the neural spines of all gradually curving backward. The transverse processes or 'parapophyses,' with the accompanying 'pleurapophyses,' belonging to nine of the included segments, approach the normal position.

"The 'centra' of the thirty-fourth and thirty-fifth divisions of the spinal series are ossified together. A single piece indicates the union of the bodies of the thirty-sixth, thirty-seventh, thirty-eighth, and thirty-ninth vertebræ, the spinous transverse processes pointing obliquely backward. The fortieth and forty-first vertebral bodies are united. The forty-second is independent. The forty-third and forty-fourth have coalesced. In these latter five instances, the supra and infra-axial developments have recovered much of their natural character.

"The twelve remaining segments of the spinal series, from the forty-fifth to the fifty-sixth inclusive, alone present a completely healthy aspect, and a glance at their uniform disposition affords a criterion of the extreme mal-arrangement to which the abdominal vertebræ have been subjected."

On the Species of Meriones *and* Arvicolæ *found in Nova Scotia. By* J. W. Dawson.

There appear to be two species of *Meriones* in Nova Scotia: one of them is identical with *M. Labradorius* of Sir J. Richardson, differing only in some trifling characters; the second species is smaller, darker coloured, and has coarser hair. The average dimensions of three adult specimens are,—length of head and body, 3 inches 6 lines; tail, 4 inches 8 lines; tarsus and foot, 1 inch 4 lines. The author had not found any description of this last species; but would not desire to name it as a new species until he had made further inquiry. Should it prove to be new, he would claim for it the name *M. Acadicus*. This species inhabits grain fields. It does not burrow, but prepares forms in sheltered places, lying very close; and, when disturbed, escaping by a few rapid leaps or bounds. It feeds by day, and does not appear to prepare any store of food for winter. It is usually stated that these elaping mice are adapted to level and open countries; it therefore appears singular that in a country originally densely wooded two species should exist. Their natural habitat may have been those places from which the woods have been removed by fire, and replaced by herbaceous plants and shrubs. The most common *Arvicola* in Nova Scotia is the *A. Pennsylvanica*, which in form and habits closely resembles the European *A. vulgaris*. It burrows, forming a neat nest, having two entrances each with a sort of antechamber to enable the animal to turn itself. It excavates galleries under the snow in winter, devouring grass-roots, bark of trees, &c.; and at the same season it often resorts to barns and outhouses. Some other specimens of *Arvicola* were exhibited, closely approaching in their characters to the *A. Novoboracensis*. The white-footed mouse, *Mus leucopus*, also occurs in Nova Scotia, and the domestic mouse and brown rat have been introduced and naturalized, while of the black rat only a few specimens have been found in the city of Halifax. It was stated that some of the specimens exhibited had been collected by Mr. Winton and Mr. Downes of Halifax.

Notes on the Homologies of Lepismidæ. By Professor Dickie, *M.D.*

The species on which the present remarks are founded is *Machilis maritima*, an insect which is common on different parts of our shores, lurking under stones and in crevices of rocks near high-water mark. It is destitute of wings, but provided with means of locomotion for running and leaping. The thoracic and abdominal zoonites present considerable uniformity in size; the former have the usual number (viz. three pairs) of well-developed limbs; the abdominal zoonites are eleven in number, and each, with the exception of the penultimate and the last, is provided with a pair of rudimentary limbs. The existence of these appendages, their resemblance to those attached to the base of the second and third pairs of thoracic limbs, and their relations to the elements of the zoonites with which they are connected, enable us to trace with facility the true homology of the parts of the ovipositor in *Machilis*.

In a series of very elaborate papers lately published in the 'Annales des Sciences Naturelles,' Lacaze-Duthiers has arrived at the conclusion that there is unity of composition in the structure of stings and ovipositors in different orders of the class of insects. From examination of a single species, viz. *Lepisma saccharina*, he concludes that in the Thysanoura, as in other orders, the ninth urite forms the ovi-

positor; the appendages of the upper arch and the sternites, together constitute the active part of the organ, and are lodged in the fissure left between the episternites.

The facility for examination and interpretation of the nature of the parts are very considerable in *Machilis*; the existence of the abdominal limbs, so obvious in that genus, enables us to see the true relations of the other parts. The ovipositor consists of four slender, flexible, and slightly club-shaped filaments, closely united to each other by means of interlocking hairs and teeth; the two outermost are evidently the sternites of the eighth urite; they are of greater diameter and length than the two others, to which they form a sort of sheath; the latter are the sternites of the ninth urite, and differ but slightly from the other two. This view of the nature of the organ does not imply that unnatural transference in position of parts which follows from adopting the other theory.

On the application (for œconomic and sanitary objects) of the principle of "Vivaria" to Agriculture and other purposes of life. By JAMES FULTON.

This paper consisted of suggestions in carrying out on a most extended field the application of glass to cultivation, on the above principle.

On the Coregoni *of Scotland. By* Sir WILLIAM JARDINE, *Bart., F.R.S.E.*

These fish form a considerable group, and in geographical distribution range chiefly over Northern Europe and North America, but are found also in Central Europe and in Great Britain and Ireland. In structure they have been generally placed with the salmon; but they are by no means typical, and differ in their large scales, the form of their mouth and minute teeth, and in their habits being more gregarious, as they are generally found in large shoals. In all these points they are related to the herring. In Scotland, the localities yet known as inhabited by the *Coregoni*, are the lochs at Lochmaben in Dumfries-shire, Loch Lomond and Loch Eke in Dumbartonshire, though from the description of fish taken in other lochs, there can be no doubt that their range is more extensive, and reaches further northward. Those of Lochmaben are undoubtedly distinct from those of Loch Lomond, but until lately those of Loch Eke were regarded as identical with the latter. The author then pointed out the differences between the three Scotch species, *C. Willughbii, C. clupeoides* and *C. lavaretus*, and exhibited specimens to the Section.

On transparent Fishes from Messina. By Professor KÖLLIKER, *Wurzburg.*

Professor Kölliker exhibited specimens and made some remarks on the structure of some transparent and otherwise peculiar fishes, recently obtained by him from Messina, viz. *Leptocephalus vitreus* and *Helmichthys diaphanus*. These fishes, when alive and in water, are so transparent as scarcely to be perceptible. In their external form they are allied to the eels, but they possess a skeleton which is only in the embryonic state.

On the Development of Sex in Social Insects. By the Rev. WILLIAM LEITCH, *A.M., Monimail Manse.*

The author commenced his researches with the view of ascertaining the circumstances that determine the development of the grub of the neuter bee into a queen. In the course of his observations, a much wider physiological question presented itself, viz. the determination of sex in general in the case of insects in which the triple distinction of sex is found to exist. He has not, as yet, satisfactorily verified his results in any social insects except the hive bee, his observations on which extend over many years. The hives he employed were a combination of the leaf hive and the thin single-comb hive, the one being readily converted into the other while the colony is in active operation. The single-comb hive was so constructed that any small portion of the comb could be readily removed, and eggs and brood transferred from one cell to another. A speculum was employed, by which, without removing the comb from the hive, the eggs and grubs, at the bottom of the cells,

might be inspected during night and day. Delicate thermometers were so constructed as to be readily applied to any particular bee or cell. The following are the principal results:—

1. Temperature is one, if not the sole element, in determining the sex of the queen. Huber ascribed the development of a queen from a neuter to special feeding, but no microscopic or chemical test can detect any difference of food. The author, however, found that the temperature of the royal cell was always higher than that of the neighbouring cells, the difference of temperature being maintained by the increased respiration of the bees clustering on the cell. The cell is also built out from the plane of the comb, so as to admit of a special temperature being maintained.

2. The queen or perfect female is *always* developed from an egg which, with ordinary treatment, would have produced a neuter. The belief has hitherto been, that the egg, from which the queen is ordinarily hatched, is different from the others, and that the power of developing a female from a neuter is altogether abnormal. This power, however, instead of being exceptional, is the normal method of producing queens.

3. The drones or males are hatched from eggs, which, without special treatment, would have produced neuters.

4. All the eggs laid by the queen are sexless, or rather bisexual. This follows from the last two results. It has been hitherto understood by naturalists that the queen lays three kinds of eggs, corresponding to the triple distinction of male, female, and neuter. The observations of the author lead to the conclusion that there is but one kind of egg, and that it depends on external circumstances which sex is to be evolved. The instinct of the bees determines the circumstances suitable for each sex, temperature being one, if not the sole determining condition; and, by respiration, they have the power of limiting a special temperature to a circumscribed space. That a female should be developed from a neuter does not now appear so startling; but, at the first announcement, the discovery was received with incredulity, and declared to be a miracle in nature. The wonder is much lessened, now, that it is admitted, that the neuter is only an undeveloped female. The development of a male from an egg that would, in other circumstances, have produced a neuter or a female, is, however, a fact of a different order. The mass of the observations were directed to the determination of this point, which may have an important bearing on the development of life in general. The result arrived at is not altogether destitute of analogy. It has been found that a plant which, under certain conditions of light and temperature, produces only female flowers, may, by altering these conditions, produce flowers of an opposite sex. Weber's discovery of traces of bisexuality as a normal fact, even in the higher mammalia, also countenances the doctrine.

5. There is a polar development of instinct in determining sex. When the instinct of the colony is excited to produce a queen, there is, at the same time, an impulse to produce drones. When the queen is removed from a hive, the colony begin to hatch, at the same time, both males and females. This polarity of instinct is still more remarkably displayed by inserting drone brood in a hive which has still a reigning queen. The presence of male brood excites the instinct to produce females, and royal cells are immediately commenced, though, from the presence of the queen, the attempt is abortive.

6. The males, in the normal condition of the hive, are hatched in large cells, and the neuters in small ones; but when the drone instinct is excited while there are no eggs in the larger cells, the drones are hatched from eggs in the smaller ones; and, in this case, they are much smaller than ordinary drones, though their organs are quite perfect. These small drones were observed by Huber, but he ascribed them to retarded impregnation. The author repeated Huber's experiments on retardation, but obtained a different result. He however could produce small drones at pleasure, by determining the instinct of the hive to the production of drones.

Singular Mortality amongst the Swallow Tribe.
By EDWARD JOSEPH LOWE, *Esq., F.R.A.S., &c.*

There has seldom been recorded a more singular circumstance than the mortality amongst the swallow tribe, which occurred on the 30th and 31st of May in the present year.

The unusually cold weather for this advanced season appears to have operated in producing the destruction of the greater number of this useful tribe of migratory birds; the severity of the weather causing a scarcity of insects (the ordinary food of the swallow), and rendering the birds too weak to enable them to search for food.

On the 30th of May the swallows became so tame that they flew about the legs of persons, and could be caught without difficulty, and on the following morning most of them lay dead upon the ground, or in their own nests.

In this neighbourhood (near Nottingham) the greatest mortality was occasioned amongst the house swallow (*Hirundo rustica*), yet solely because this bird predominates.

Near the Red-Hill Tunnel at Thrumpton, there are great numbers of sand-martins (*Hirundo riparia*), and there in a saw-pit on the banks of the river Soar, hundreds congregated and died.

At Borrowash, near the Derwent river, there are very many white-martins (*Hirundo urbica*); they also congregated and died, lying ten and twelve deep on the different window-sills. Several persons opened their windows, and the birds were very willing to take shelter in the rooms, exhibiting no disposition to depart. Many were kept alive in the different houses by being fed with the *Aphis* of the rose-tree, the only procurable insect.

At Bulwell, Wollaton, Long Eaton, Sawley, and many other places, the same fearful mortality occurred. Farmers opened their barn-doors to admit the birds. To show the extent of the deaths, it may be mentioned that at one place, where previously there were fifty nests occupied, only six pair survived to take possession of them.

The manner in which they congregated was a curious feature in the occurrence. A swallow would fly round a heap of dead and dying companions, and then suddenly dart down and bury itself amongst them.

On the same days, in the Vale of Belvoir, and in parts of Nottinghamshire and Lincolnshire, several hundred newly-shorn sheep perished.

A brief account of the weather at Highfield previous to the 31st of May will prove interesting.

May.	Maximum Temperature in Shade.	Minimum Temperature.	Mean Temperature.	Greatest cold on grass.	Range of Temperature.	Direction of the wind.
26.	81°·9	54°·4	65°·1	45°·0	27°·5	E.
27.	70·0	51·6	56·8	47·5	18·4	E.
28.	61·8	43·0	49·3	40·2	18·8	E.
29.	56·1	38·8	44·8	36·0	17·3	N.
30.	50·0	35·0	40·4	30·5	15·0	N.
31.	44·7	37·8	42·0	37·2	6·9	NE.

During these six days the barometer ranged between 29·6 inches and 29·9 inches. The first three days were very fine, and during the whole time there was much ozone. 29th, electricity active from 11 A.M. till noon. 30th, boisterous wind with hailstorms. 31st, boisterous wind with continued rain. On the 30th there was a frost.

It would be interesting to trace over what extent of the island this mortality was noticed.

Exhibition of Zoophytes, Mollusca, &c., observed on the Coast of Norway, in the Summer of 1855. *By* Robert M'Andrew, *F.R.S.**

A few of the species of mollusca were new: many were not recorded to have been previously obtained from the locality, whilst others exhibited peculiar forms of well-known species.

* Mr. M'Andrew was requested to draw up a report on the results of his various dredging excursions.

Some Remarks on the Fauna of the Clyde and on the Vivaria now exhibited in the City Hall, Glasgow. By the Rev. Charles P. Miles, *M.D., Glasgow.*

The author made some remarks on the distribution and habits of the invertebrate animals of the Clyde, and showed specimens of the more remarkable species which had been collected together in the large tanks of sea-water under his direction in the City Hall for exhibition during the Meeting. He also drew attention to the various forms of Zoophytes, Mollusca, Crustacea, and Echinodermata,—including *Comatula rosacea, Luidia fragilissima, Æga tridens, Plumularia pinnata,* &c., as among the more interesting and rare.

On the Recent Additions to our Knowledge of the Zoology of Western Africa. By Andrew Murray, *Edinburgh.*

After referring to the fact that so little was known of the natural history of Western Africa, he proceeded to say—I should not have thought of making any communication on the subject, had it not been for a new source of information which has been opened to the Scottish naturalists within the last two or three years, which I have thought it might be useful to our southern friends to be made aware of, as a means likely to supply much of the information we want upon at least one part of the coast; and I hope also to serve as an example which may produce similar results elsewhere—I allude to the mission stations which have been established at Old Calabar. It is only two or three years ago since the Rev. H. Waddell, on his temporary return to this country, brought with him, besides other objects of interest, a few bottles of snakes and insects. These were exhibited to the Royal Physical Society of Edinburgh in December 1852; and every encouragement was given by the members of that Society to Mr. Waddell to proceed in the working of what promised to turn out a mine of interest. They enlisted Mr. Goldie and Mr. Thomson in the pursuit; and the consequence has been that there has already been received from these gentlemen a large amount of interesting new species,—a number of which have since been described and published, and others of which are in course of preparation for publication.

Mr. Murray then briefly drew attention to such additions to the natural history of Western Africa as had been recently made. He said—Little has been done in the Mammalia. M. Dureau de Lamalle has published in the 'Annales des Sciences Naturelles' some particulars regarding the Great Chimpanzee, or *Troglodytes Gorilla,* found in the river Gaboon; and in 1823 Dr. Kneeland of Boston published details of the skeleton of this species. Mr. Fraser, after his return from the Niger Expedition in 1843, published in the 'Proceedings of the Zoological Society,' a description of a new Bat from Fernando Po, as well as a new Pouched Rat from the same place. Dr. J. E. Gray described in the same 'Proceedings,' a new *Manis*; and in 1852 he described in the 'Annals of Natural History,' a new Wart Pig (*Cheiropotamus pictus*) from the Cameroon river. As to ornithology, more has been done of late years. A considerable number of new species were brought home by the officers of the Niger Expedition above referred to, and were described partly by Mr. Strickland and partly by Mr. Fraser. And more recently, M. Verraux has described a number of species from this coast. Several of these were received from Old Calabar simultaneously (or nearly so) with their publication by M. Verraux.

A number of new fishes has been received from Old Calabar, the most interesting of which is an electric fish, a Silurus, which I have described and published under the name of *Malapterurus Beninensis.* In addition to the information which is given in my account of the fish in the 'Edinburgh New Philosophical Journal,' I have since received some additional particulars from Mr. Thomson. He informs me that its electrical properties are made use of by the natives as a remedy for their sick children. The fish is put into a vessel of water, and the child made to play with it; or the child is put into a tub of water in which several fishes are placed. It is interesting to find a popular scientific remedy of our own, anticipated by the unlettered savage. Mr. Thomson also mentioned an instance of the electric power of this fish, which may be worth mentioning. He had a tame heron, which, having been taken young, had never had the opportunity of searching for and choosing its

food for itself. It was fed with small fishes; and on one occasion there happened to be a newly-caught electric fish among them, which it swallowed, but immediately uttered a loud cry, and was thrown backwards. It soon recovered, but could never afterwards be induced to dine upon *Malapterurus*. This species I believe to be found all along the Guinea coast. Dr. Baikie informs me that he had seen a small species at Fernando Po, which appeared to him to correspond with the description of this species. Among other interesting fish sent by Mr. Waddell, there is a species of *Lophius*, or mud-fish, which appears undescribed. The curious habits of this semi-amphibious family, of crawling out of the water, using their fore fins like legs, and then sitting staring about with their great goggle eyes, is noticed by Mr. Waddell as very marked in this species. If placed in a basin, it will crawl up the side, and sit on the edge, looking about. A new pipe-fish has also been received, as well as some other species of fishes which I have not yet had the opportunity of determining. A very considerable number of snakes, lizards, &c. have also been sent. Among the lizards there was a new Monitor, which Dr. Lowe exhibited to the Royal Physical Society, approaching near to the *Monitor pulcher* of Leach (now recognized as a variety of the *M. niloticus*, Linn.), besides specimens of the chameleon.

As to the Mollusca, Dr. Greville not long ago exhibited to the Royal Physical Society a very interesting collection of land and freshwater shells, which had recently been transmitted to him by the Rev. Mr. Goldie. *Bulimus Wrightii* was the most valuable shell of the series,—a handsome species, then described only a few months before by Mr. Sowerby, jun., from a single specimen picked up by a shipwrecked sailor. Other species of the same genus were *B. Numidicus* (Reeve) and *B. spectralis* (Reeve); of *Achatina* there was *A. striatella* (Rang), and a large one which Dr. Greville had been unable to determine, nearly allied to *A. marginata*, but more ovate in form, and distinguished by a red pillar. There were also three small *Helices*, belonging to sections difficult of determination, one of them probably new. Fine specimens occurred of *Melania Owenii* (Gray), which appears to be generally distributed in Western Africa; and of *M. mutans* (Gould), which Dr. Greville had previously received from Liberia. *Neritina Perrottetiana* (Recluz), and a fine bivalve, probably a Cyrene, were the remaining forms.

In Insects, however, more has been done than in any other branch. I shall not go back to the insects of Angola, described by Erichsen about ten years ago, or the species from Congo, described by Mr. White about the same time; but I think I may be excused for referring to Westwood's 'Arcana Entomologica,' although a few years have elapsed since its publication, seeing that the most attractive part of that work is occupied with the West African Goliaths, of which the largest and finest species known is the entomological ornament of this University (the almost unique specimen of the *Goliathus giganteus*).

Very large collections of Coleoptera have been received from our correspondents in Old Calabar; so much so, that we are now in a position not only to make up a pretty accurate list of the Coleoptera of that country, but also to form an opinion as to their relative numbers. Such a list I am in the course of preparing, intercalating descriptions of the new species as they occur; and, as a large proportion of them are undescribed, the new information will be considerable. Before I thought of doing so, however, I had supplied my friend M. Chevrolat (who is our great authority in Longicorns) with a set of the new species of that group, and he has lessened my task by describing nearly fifty of them in Guérin's 'Revue Zoologique.' As is always the case in warm climates, the Geodephaga are comparatively few, both in number of species and individuals—the whole number of species which I have received not exceeding fifty. One or two very fine species, however, occur among them. No *Hydro-cantharidæ* have been received. This may arise from their not having been sought for. But I am inclined to think that, in point of fact, the water-beetles are not numerous in these latitudes. As might be expected, the burying beetles have not been found there; the climate would not allow their nidus to remain as food for the larvæ long enough for their growth—a consideration, which suggests to me a curious change in habit suited to the climate, which was mentioned to me by Mr. Thomson regarding the *Aphodii*. In this country, as entomologists are aware, that family lay their eggs in dung, in which the larvæ feed until

they come to maturity, and then descend into the earth to undergo their transformation; and in walking over the fields we find every patch of dung swarming with their larvæ. At Old Calabar we could find nothing of this. The heat is so great that in a couple of days the patch of dung would be quite dried up. The *Aphodii*, therefore, have a different habit. As soon as the dung has been dropped, they come, and each bores a hole under it; and carry down a small quantity there to feed, and lay their eggs; so that they, at one and the same time, clear away the refuse from the ground, and apply it as manure to the roots of the plants.

As already mentioned, the Longicorns have furnished a considerable number of novelties, many of great beauty; but with the exception of one or two species, which occur in quantity, the individuals have been very scarce. It is, however, in the *Phytophaga* that nature seems to have most revelled here. Their number is great both to individuals and species, and a great portion of them are undescribed. Many new genera also occur. The number of brilliant little *Cassidæ* is also remarkable. The *Heteromera* are numerous in individuals; not so much so in species. A number of Mr. Westwood's recently described species have occurred. Of the *Brachelytra* no representatives have been found. A single new *Paussus* (named *Paussus Murrayi* by Westwood) has also been found. Members will recollect that it was on this coast that the first *Paussus* known was met with. Afzelius was sitting at table in the dusk, when a small insect dropped upon his paper, carrying two globe-shaped antennæ like coach-lanterns on its head, both giving out a feeble light. This was the *Paussus sphærocephalus*. Mr. Westwood has since described a large number of species; and he seems to question the accuracy of Afzelius, so far as regards the light given out by the antennæ, as that has not been observed since, and many of the species have hard and untransparent globes on the antennæ. The globes in Afzelius's species, however, are semi-transparent; and the habit of life of many of them would seem to render their luminosity not improbable, for they live in ants' nests, and it would surely be very convenient to have a pair of lanterns fastened like a Davy lamp on their head, to light them on their way through the dark galleries. If it is so, it shows how diversely nature sometimes acts under the same circumstances. Here she provides a light for the darkness; while in other instances, where species live wholly in the dark, as in the caves of Carniola, Kentucky, &c., and in the genus *Claviger*, which lives in ants' nests, she takes away their eyes altogether as useless appendages. The *Hemiptera* are largely represented in Old Calabar. A great proportion of them are undescribed; but M. Signoret has undertaken to describe the most striking of the new species, and has already described and figured one or two in the 'Annals of the Entomological Society of France.'

There seem to be a good many spiders. A large Mygale was exhibited to the Royal Physical Society by Mr. Logan; and the species of *Epeira clavipes*, described by Palissot de Beauvois, appears common. Dr. Lowe of Edinburgh also described two species of gigantic Iulus. A word regarding the geographical relations of the insects of this country. The most striking circumstance is the relationship of many of them to South American species. We not only find many representatives of American genera, but actually species of genera hitherto only known as South American; and in some instances even the same species occurs, such as *Mallodon maxillosum*, *Bostrichus muricatus*, &c. Putting aside these latter as being wood-feeders, and therefore capable of being introduced by floating across the ocean, we have the genera *Galerita*, *Parandra*, *Œme*, *Smodicum*, and others now containing African species. This, however, is a subject which deserves more extended observation before any sound deduction can be drawn from it.

Mr. W. Oliphant, Treasurer, R.P.S.E., exhibited the skull of a *Manatus Senegalensis* (the Sea Cow), for which he was indebted to Mr. Thomson, from Old Calabar. The skull, which was that of a young animal, the teeth not being fully developed, was interesting, as it was from comparing their crania that Mr. F. Cuvier had ascertained that the *M. Senegalensis* of the West Coast of Africa was a different species from the *M. Americanus*, which frequents the rivers on the other side of the Atlantic. He regretted not being able to make any addition to the rather scanty knowledge we possess of the history and habits of this species, but mentioned a

curious fact as to the high estimation in which it is held by the natives. All the Manati in the Calabar waters belong to Egbo, and before any one can become a member of this remarkable institution, it is necessary that he procure one of these animals for the feast which takes place on his admission. This Egbo Society exercises a very important influence in the country, being, in fact, the great governing power, as from it all the laws regulating both civil and religious matters emanate. It was by an Egbo law passed within these three years that an end was put to the wholesale murders which were committed on the death of a chief by the Ordeal Bean, of which an interesting account by Prof. Christison appeared in a late Number of the 'Edinburgh Medical Journal.' Admission to Egbo is obtained by purchase, and all the leading men are members. It is divided into shares, of which any individual may hold as many as his means will enable him to acquire. At his death one share drops, but the others vested in him are inherited by his relatives; in this way, as each share confers a vote, large political power may become concentrated in one person. Eyo Honesty, the present king, a shrewd and sagacious man, who has obtained his surname by the integrity of his dealings with the numerous traders who frequent his river, purchases a share whenever he can procure a Manatus, and has thus a large sum of money invested in it, from which he derives a considerable, though somewhat precarious revenue. Calabar is steadily advancing in civilization, and its progress would be much accelerated were it not for the barrier which this powerful body presents. Eyo is aware of this, but as he holds a large stake in the concern, he, like other potentates, is somewhat conservative of old customs, and though he has admitted some slight ameliorations in its mode of operation, will allow no material change in its constitution. Admission being dependent upon the acquisition of a Manatus, the capture of one of these animals is a prize of no small value. The species is said to attain the size of from 12 to 15 feet in length, and its flesh, which much resembles veal, is esteemed a great delicacy by the natives. In Calabar, the elephant, hippopotamus, leopard, and boa constrictor, are deemed royal property, and are denominated in the broken English of the country "King Beef." Lately a serious disturbance was like to occur in consequence of the Ekri Tobacco people having devoured a small portion of a putrid hippopotamus which had been shot by one of King Eyo's men, and had been carried by the current to their neighbourhood. The inhabitants of the village only escaped by the payment of a heavy fine to Egbo. Mr. Oliphant said he had mentioned these particulars, as they were not likely to come under the notice of the naturalist.

Notes on Animals. By J. Price.

The author offered directions for aërating the water of the marine aquarium by means of a moving tank, and suggestions for removing putrid matter from the water.

On Sea Medusæ. By J. D. Sandland.

On Vivaria. By N. B. Ward, *F.R.S.*

The object of the author was to show that the cases for growing plants and the tanks for cultivating plants and animals in water, which he had first suggested, had perfectly succeeded in all the objects for which he had first proposed they should be used. He read several letters from persons who had extensively employed them, and concluded by urging a much more extensive use of them than had been hitherto undertaken.

On the Habits of the Stickleback, and on the Effects of an Excess or Want of Heat and Light on the Aquarium (Marine). By Robert Warington.

In the latter paper the author points out that temperatures below 45° destroyed many forms of animal life, especially crustacea, whilst a temperature exceeding 75° Fahr. was destructive of both animal and vegetable life. Too great exposure to light was also found to be injurious to many creatures kept in the Marine Aquarium*.

* Dr. Fleming related, in connexion with the subject of keeping animals in sea-water, that he had in his possession an *Actinia*, originally captured by Sir John Dalyell, that had now been in captivity twenty-eight years.

Dr. Lankester exhibited the model of a dredge, invented by Mr. Dempster.

Exhibition of a Copy of the 'Natural History of Deeside and Braemar,' by the late Dr. Macgillivray, *and edited by* Dr. Lankester.

The manuscript of this work had been purchased by the Queen, and was now published by Her Majesty's command. The work consists of an account of a personal tour made by the author in 1853, lists of the plants, animals, and minerals, and a complete map of the district, with woodcuts illustrative of the scenery in the neighbourhood of Balmoral.

On the Cultivation of Sea-sand or Sand-hills. By the Rev. Dr. Paterson, *of Glasgow.*

Dr. Lankester exhibited a series of photographs on glass, of various histological and natural history objects, executed by Dr. Redfern, of Aberdeen. They were done according to the suggestions made by Mr. Wenham at the last Meeting of the Association at Liverpool.

Mr. Patterson exhibited a series of Zoological Diagrams prepared by him for the Government Department of Science and Art.

Physiology.

On the signification of the so-called Ova of the Hippocrepian Polyzoa, and on the Development of the proper Embryo in these Animals. By Professor Allman, *F.R.S.*

The author maintained that the peculiar egg-like bodies which are found so abundantly in the endocystal cavity of almost all the Hippocrepian Polyzoa, and which had been hitherto universally viewed as ova, are not ova, but *gemmæ*, peculiarly encysted, and destined to remain for a period in a quiescent pupa-like state. The very earliest stages of their development are all that can be followed, as they soon become enveloped in an opake horny investment which entirely conceals all internal structure. From such examination, however, as they admit of, it can be seen that they never present the least trace of germinal vesicle or germinal spot, nor do they undergo segmentation. After a time the horny covering splits into two valves, and allows the young polyzoon to escape, in all essential points resembling the adult, and never presenting the general ciliated surface which is always found in the true embryo. The bodies under consideration are invariably produced in the long chord or funiculus which connects the fundus of the stomach of the polypid with the bottom of the cell, and are plainly developed as buds from its substance. They may be seen in regular stages of growth from the proximate to the remote extremity of the funiculus, being younger as they recede from the stomach. The funiculus, with its peculiar gemmæ, reminds us of the gemmiferous stolon in the interior of the solitary individuals of *Salpa*. To the bodies in question, the author proposed to give the name of *statoblasts*. They present a striking analogy with the so-called "ephippial ova" of *Daphnia*, and the "winter ova" of the Rotiferæ, which latter have been already brought into the category of gemmæ by Huxley (Quarterly Journal of Microscopical Science, October 1852). While the characters of the statoblasts are thus much more in accordance with those of gemmæ than of ova, their real nature appears to be entirely set at rest by the fact that there also exists in the Polyzoa a true ovary with genuine ova. The author has made out this organ very distinctly in *Alcyonella*. It is there developed in the walls of the endocyst, near the anterior extremity of the cell. It appears as a slightly pedunculated roundish mass, filled with spherical ova, each presenting a large germinal vesicle and very distinct germinal spot. The ovum undergoes segmentation, and soon after the mulberry-like

condition has disappeared, we find that the contents have assumed the form of a roundish or oval embryo, richly ciliated on its external surface, and with a large central cavity. When liberated from the external membrane of the ovum, which still confines it, it swims actively through the surrounding water. As development proceeds, we find this ciliated body to present an anterior opening, through which an unciliated hernia-like sac is capable of being protruded by a process of evagination; and there is evidence to support the opinion that this protrusible non-ciliated portion has been separated from the inner surface of the ciliated portion by a kind of *unlining*. In the interior of the protrusible portion, the polypid is developed in a manner which appears altogether similar to that by which new polypids are produced by gemmation from the walls of the endocystal cavity of the adult. The protrusible or non-ciliated portion remains for a time incapable of complete evagination, the posterior part of it being retained in a permanently invaginated state, by bands which pass from it to the opposed surface of the ciliated portion in a manner exactly similar to that by which the permanently invaginated part of the endocyst in the adult is retained in its place by the parieto-vaginal muscles. As development continues, these bands disappear, and the invagination with which they were connected becoming obliterated, the non-ciliated portion becomes *directly* continuous with the ciliated, and incapable of being any longer withdrawn within it. The cilia now disappear, and the entire sac becomes enveloped in an ectocyst to constitute the cell of the adult polyzoon. The subsequent changes are produced by the gemmation of new polypids.

The testis is developed in the form of an irregular roundish mass upon the funiculus, and frequently co-exists with statoblasts. It is composed of spherical cells, each of which contains within it numerous "vesicles of evolution." The visible contents of the vesicles of evolution are at first confined to a well-defined spherical nucleus, and this is afterwards transformed into a spermatozoal filament, which subsequently escapes by the rupture of the containing cells. The escaped spermatozoa in *Alcyonella* present distinct, though not very active undulatory motions. They are simple filaments of uniform diameter, and destitute of capitulum.

On the Law of Molecular Elaboration in Organized Bodies. *By* Professor J. Hughes Bennett, *M.D., of Edinburgh.*

When the Association met in Edinburgh, the author pointed out to the Physiological Sub-section,—1st, how molecules are being continually formed in the body from the union of oil and albumen, from the results of endosmose and exosmose, and from various chemical combinations; 2ndly, certain facts with regard to the peculiar movements of these bodies—the molecular motions of Brown; and 3rdly, how they unite to form nuclei, fibres and membranes directly, independently of the agency of cell formation. He also pointed out that the process of degeneration was exactly inverse to that of formation, and that the last as well as the first histological form was the molecular.

Subsequent research as to the behaviour of these molecules induced him now to put forth the following law, viz. *that the formations and transformations of the various textures of the body not only take their point of departure from molecules, but are brought about by successive buildings up and breakings down of masses of molecules.*

By the term molecule or granule, the author did not mean a cell or nucleus, but those smaller particles which are only distinguishable optically under high powers by exhibiting a bright or dark centre, and a dark or bright border, according to the focal point in which they are viewed. Organic molecules consist of a mixture of some proteine compound with oil.

He then referred to various well-known facts with a view of demonstrating that ultimate form and composition were arrived at by a succession of formations and disintegrations, and that when a new arrangement of parts took place this was effected through the agency of molecules. He described,—1st, the mode of development of *Ascaris mystax* as detailed by Nelson; 2ndly, that of the mammalian ovum as described by Barry and Bischoff; 3rdly, the mode of development in uni-cellular plants and animals; 4thly, the transformations of insects; 5thly, the formation of

blood from the prepared food; and 6thly, the production of morbid growths from an exuded blood-plasma. All of which, with many others that might have been brought forward, point out that from organic molecules, nuclei and cells are produced, and that these break down once again to form molecules. From this second mass of molecules other cells are formed, which again break down to form a third mass of molecules, and so on; and by this law of molecular elaboration the various textures are ultimately produced.

Lastly, he endeavoured to illustrate how these formations and breakings down, and a knowledge of this law must constitute the only real scientific basis for the arts of horticulture, agriculture, and medicine; moreover, that in the chain of living processes each step is dependent on the one that precedes it; and that, inasmuch as regards form, we cannot go further back than the molecular element, so a knowledge of it must be the first step to a correct theory of organization.

The Physiology of Fascination.

By JAMES BRAID, *L.R.C.S. Edin., M.W.S. &c., Manchester.*

The power possessed by serpents to fascinate birds has always been a source of interest and admiration to the curious. That a crawling reptile, such as a serpent, doomed to move pronely on the earth, should possess the craft and power, by the mere fixed gaze of its glaring eyes, irresistibly to draw down from their proud aërial perch the very fowls of heaven, seems to proclaim this as one of the most remarkable of nature's laws, which has ordained that extremes should meet. The question therefore arises, by what means is this remarkable result effected? Is there any magnetic attraction in the eye of the serpent by which the bird is drawn? or is it the result of any poisonous emanation projected by the serpent? Is it a voluntary or an involuntary process, by which the creature approaches and falls an easy prey to its fell destroyer?

I shall at once proceed to state what appears to me to be the true explanation of the phænomenon—one which is quite in accordance with nature's laws, and which, moreover, explains, on scientific principles, some remarkable phænomena observed even in man.

From various observations which I have read and heard on the subject, I feel satisfied that the creatures fascinated do not *voluntarily* surrender themselves to their fate; and this I consider is proved by the agitation and alarm which many of them display when advancing to meet their fate, viz. their plaintive cries, and the agitation of their bodies, and the instant escape which they make when any circumstance has occurred to avert from their sight the glaring eyes of the serpent. Their ability to escape so speedily, moreover, under such circumstances, proves that the charm had not been the result of any magnetic attraction, or poisonous emanation proceeding from, or projected by, the serpent. After due consideration, I feel satisfied that the approach and surrender of itself by the bird, or other animal, is just another example of the *mono-ideo-dynamic*, or unconscious muscular action from a dominant idea possessing the mind, which is also the true cause of "table-turning."

The law upon which these phænomena are to be explained has long been familiar to me, from observations made during my investigation of hypnotic and mesmeric phænomena, and it is simply this—that when the attention of man or animal is deeply engrossed or absorbed by a given idea associated with movement, a current of nervous force is sent into the muscles which produces a corresponding motion, not only *without* any conscious effort of volition, but even in *opposition* to volition, in many instances; and hence they seem to be irresistibly drawn, or spell-bound, according to the purport of the dominant idea or impression in the mind of each at the time. The volition is prostrate; the individual is so completely *mono-ideised*, or under the influence of the dominant idea, as to be incapable of exerting an efficient restraining or opposing power to the dominant idea; and in the case of the bird and serpent, it is first wonder which arrests the creature's attention, and then fear causes that *mono-ideo-dynamic* action of the muscles which involuntarily issues in the advance and capture of the unhappy bird. This is the principle, moreover, which accounts for such accidents as are frequently witnessed in the streets of every

crowded thoroughfare, where some persons, when crossing the streets amidst a crowd of carriages, not only become spell-bound by a sense of their danger, so that they cannot move from the point of danger, but it even sometimes happens that they seem impelled to advance forward into the greater danger from which they are anxious to escape, and from which a person with more self-possession or presence of mind may be forced, by the very sense of his danger, to escape, by making an incredible bound—his natural powers having become stimulated to unwonted energy, by a lively faith having taken possession of his mind as to his capability to accomplish such a feat. It is this very principle of involuntary muscular action from a dominant idea which has got possession of the mind, and the suggestions conveyed to the mind by the muscular action which flows from it, which led so many to be deceived during their experiments in "table-turning," and induced them to believe that the table was drawing them, whilst all the while they were unconsciously drawing or pushing it by their own muscular force. As already remarked, it is upon this principle that the bird is drawn to its fell destroyer, and, moreover, that human beings may appear deliberately and intentionally to leap over precipices, and cast themselves from towers and other situations, not only of danger, but of certain destruction. It is also upon the same principle that some individuals may be brought so much under the control of others, through certain audible and visible and tangible suggestions by another individual, as is seen in the phænomena exhibited in the waking condition, in what has been so absurdly called "electro-biology." The whole of these phænomena of "electro-biology," of "table-turning," the gyrations of the odometer of Dr. Mayo, of the magnetometer of Mr. Rutter, the movements of the divining rod, and the supposed levity of the human body lifted on the tips of the fingers of four individuals, as described by Sir David Brewster, the fascination of serpents, the evil eye and witchcraft, and the charm by which a fowl may be fixed and spell-bound by causing it to gaze at a chalk line, or strip of coloured paper, or of white paper on a dark ground—all come under the same category, namely, the influence of a dominant idea, or fixed act of attention, absorbing, or putting in abeyance for the nonce, the other and great controlling power of the mind—the *will*.

My investigations have proved, beyond all controversy, that by these means the ordinary mental and physical functions may be changed, so that the subject shall lose his freedom of action, and that *all* the natural functions may be either excited or depressed with great uniformity, even in the waking condition, according to the dominant idea existing in the mind of man or animal at the time, whether that has arisen spontaneously, has been the result of previous associations, or of the suggestions of others. The whole of the subsequent abnormal phænomena are due entirely to this influence of dominant ideas over physical action, and point to the importance of combining the study of psychology with that of physiology, and *vice versâ*. I believe the attempt made to study these two branches of science so much apart from each other, has been a great hindrance to the successful study of either.

On the Action of the Carbo-azotic Acid and the Carbo-azotates on the Human Body. By Professor CALVERT *and* Dr. THOMAS MOFFAT.

On an abnormal Condition of the Nervous System. By WILLIAM CAMPS, *M.D.*

The author stated that the object aimed at in this communication was to present to the Section a remarkable, if not unique condition of the nervous system, as observed in a female aged fourteen years. He described it as an instance of *irregular intermittent tetanic catalepsy*. Although the subject of this catalepsy resided some sixty or seventy miles from London, yet he had seen the young woman on two separate occasions, thus affording him opportunities of witnessing the various phænomena connected with this abnormal condition of the nervous system. By this means, he had seen her whilst *waking up out* of a profound cataleptic slumber, *during* her waking state, and also *in* the cataleptic slumber. She had continued in this state throughout a period of nearly twenty weeks, during which he had been informed she had taken but very little nourishment. The conditions of the voluntary

muscular apparatus during these several states, as well as other functions of the body, were described by the author of the paper. The various properties of the nervous system, as here exhibited, were remarked upon and severally discussed, such as *sensation, volition, consciousness,* and *intelligence.* She sometimes would awake every day, for half an hour or so, and sometimes her slumber would continue undisturbed for days; but always when asleep, the greater part of her body was in a state of tetanoid rigidity, which however totally disappeared on awaking. The author considered this muscular contraction to be *automatic* and not *voluntary*; he thought too, that *consciousness* was only partially, and not totally absent, even in her profoundest slumber.

On a curious pouched condition of the Glandulæ Peyerianæ in the Giraffe. By Dr. T. Spencer Cobbold.

Professor Allen Thomson exhibited, on behalf of Dr. Cobbold, Assistant Conservator of the Anatomical Museum, University of Edinburgh, a preparation of part of the cæcum and colon of a giraffe. The specimen showed a complicated series of pouches in connexion with the last patch of compound intestinal glands, which extended beyond the ileo-colic opening, and the whole formed a cellular network, resembling in some measure the water cavities of the reticulum. A second specimen was also shown, from which it appeared that certain of the Peyerian patches in the ileum likewise displayed each a simple valvular fold at the duodenal extremity of the glandular masses.

On the Sexuality of the Algæ. By Dr. Ferdinand Cohn, *of Breslau.*

In this paper the author first referred to the influence which the newer doctrines of cell-structure and formation had exercised on the progress of animal and vegetable physiology, and pointed out the peculiar advantages presented by the unicellular plants for the investigation of some of the more hidden vital processes. He then sketched the recent progress of discovery as to the sexuality of different tribes of plants formerly regarded as Cryptogamic. Among the most novel of these discoveries, he referred more particularly to the researches of Thuret of Cherbourg, on the Fecundation of the Fucaceæ (1855), which have incontestably proved the occurrence of a sexual fecundation in some of the larger Fuci; and to the observations of Pringsheim of Berlin, also in 1855, which have first extended the same discovery with certainty to some of the lower Algæ (*Vaucheria*). The author stated that he had not only been able to confirm the observations of Pringsheim on these plants, but had himself nearly at the same time (in March 1855) made the discovery of similar phænomena in others of the lower Algæ, *Sphæroplea annulina,* &c.

In this beautiful and delicately organized Conferva the contents of the thread-like plant are arranged in the form of about twenty green rings in each cell. They consist, like the spiral bands of *Spirogyra,* of slimy protoplasma coloured by chlorophyll, and containing a large number of starch-granules. In the month of March, when the time of propagation had arrived, Dr. Cohn observed the cells of this plant to undergo a remarkable transformation, by which some become converted into sporangia and others into antheridia. In the first of these bodies the green rings dissolve as it were into a shapeless mass, from which about as many green globular bodies or spores are found as there were previously rings; and when these are complete, several small apertures appear in the wall of the mother-cell. In the other cells which are about to become antheridia, the green rings became, under Dr. Cohn's observation, actually broken down and converted into small red stiff corpuscles, each of which bears at its anterior extremity two long fine vibrating filaments. These bodies, which are the spermatozoa, then assume the swarming motion; soon one or more escape by a small aperture in the cell-wall, and all the rest follow, and they move with vivacity in the surrounding water. They approach the spore-cells, and some of them soon penetrate by the apertures already formed in them; others follow, and thus the spore-cells become quite full of them. Dr. Cohn observed the spermatozoa moving about within the spore-cells for two hours, after which they affixed themselves to the surface of the spores and disappeared by diffluence in slimy

drops, which seemed to be absorbed into the spores. As soon as this has occurred, each green spore-globule, previously naked, becomes covered with a clear glassy membrane, its colour changes to red, and other coverings are formed successively within the outer one. Finally, the red spore-globule is enclosed in a peculiar stellate wall.

In another Conferva belonging to the genus *Œdogonium*, a singular mode of fecundation has also been observed by Dr. Cohn. The ciliated "macrogonidia" of this Conferva have long been known: this germinates into a long cellular thread. The other sexual element of this plant consists of the so-called "resting-spores," which are red globular bodies enclosed by a thick wall. But Dr. Cohn has observed that the "microgonidia," which were detected by Alexander Braun, undergo a sort of germination, and by this produce two small agile spermatozoa, which penetrate the sporangium cells through a small aperture (which had been seen by Pringsheim), and adhering to the spore, thus probably effect fecundation.

The principal difference between the propagation of *Œdogonium* and that of *Vaucheria* and *Sphæroplea* consists in this, that while in the two latter the fecundating corpuscles (spermatozoa) are directly produced, and the male and female organs are united in one confervoid individual, in the *Œdogonium* the moving bodies are to be regarded rather as gonidia, which are destined to germinate like the great gonidia. But from the microgonidia there issue the minute male individuals, consisting each of a small cell, of which the whole contents are changed into spermatozoa. The great gonidia (macrogonidia) germinate into large plants, consisting of numerous long cells and generating the resting-spores.

The observations of Braun and Pringsheim already show that similar phænomena must occur in others of the Confervæ; and, according to Dr. Cohn, it seems very probable that the fact of sexuality, although at present proved only of a few genera of the Confervæ, will very soon be discovered in all other kinds; and that an act of fecundation will be shown to occur in the simplest unicellular plants. In various plants, one or other of the reproductive elements have been discovered singly, as in *Chætophora* and *Hydrodictyon*; but already enough is known to point to the destination of these bodies.

Dr. Cohn indicated the probable future progress of inquiry in respect to these functions also in the Volvocineæ, Florideæ, Zygnemeæ, Desmidieæ, and Diatomaceæ. From these considerations the author drew the general conclusion, that sexual difference and an act of impregnation are the necessary conditions of reproduction of all plants from the highest to the lowest, and he regards it as probable that the same will ultimately be proved of the lowest or infusorial animals.

An attempt to solve some of the Difficulties of the Berkleyan Controversy by well-ascertained Physiological and Psychological Facts. By RICHARD FOWLER, *M.D., F.R.S.*

The Berkleyans contend that we have no knowledge of matter but by gratuitous inference from subjective sensation; that, in reality, the mind has no direct perception of anything but of impressions, conceptions or ideas.

The generality of mankind, however, instinctively believe that impressions on our organs of sense, like impressions on wax by a seal, are made by objects external to the mind: such objects are supposed to be modifications of matter. It therefore becomes necessary to ascertain what matter may really be. Berkley said there was no matter; and it was wittily replied, "It is no matter what Berkley said." In our conceptions we have all the forms and colours and dimensions of matter, but they are wanting in the impenetrability assigned to matter, and in the periodicity by which some of its phænomena are noticeable—as the revolution of the planets, admitting of mathematical calculation, while our conceptions are fleeting, uncertain and evanescent,—come when they are least expected, and, in emotions, particularly fear and remorse, resist all the efforts of volition to exorcise them.

The question then recurs, what is matter? Its impenetrability has been supposed to consist in a nucleus surrounded by spheres of attraction and repulsion. But as it is useless to assign more causes of the fact than are necessary to produce it, philosophers, Newton, Boscovich, Priestley and others, have, the author thinks, experi-

mentally shown that these nuclei never can be brought in contact with each other, and that all the phænomena attendant on compression and adhesion can be explained by the atomic forces of attraction and repulsion. It was therefore the conclusion of Boscovich, that the attractive and repulsive forces might have no other common centre than mere mathematical points.

It would appear, then, that we have no knowledge of any external cause of our impressions on our mental force but by the vital and physical forces. For example, we have no sensation from mere contact of objects; we must move to feel; we have, then, sensation by our muscular sense. We must look to see, listen to hear, sniff to smell, and move the organs of the mouth to have the sensation of flavour.

Matter, then, seems to have been, not without reason, considered by Turgot, Prof. John Robison and Prof. Dugald Stewart as the mere cause of the phænomena which are believed by us to be real, external and palpable objects.

But is it possible that any such appearance can be produced by any combination of mere forces?

This is no idle question of mere curiosity; it bears on the very foundation of our hopes of a future life. We have all the evidence which the present state of this world can give us, that the forces by which its phænomena are effected have always existed, and are likely always to continue to exist—the immediate agents of the Deity; so immediate, indeed, as to be considered by many profound thinkers (Malebranche and Norris) as evincing the presence of Deity itself, and that all our perceptions are impressed by the conceptions of the Deity.

It must be borne in mind that "quicquid recipitur, modo recipientis recipitur." Well, therefore, might Turgot, Robison, Dugald Stewart, and all philosophers who have given a candid consideration to the speculations of Berkley, say that we cannot, indeed, prove or deny the existence of matter external to the mind. We are bewildered by phænomena for which we are at a loss to account. The author's solution of the difficulty, after much consideration, is, that these phænomena are produced by impressions by physical and vital forces external to the mental force, but in immediate proximity and communication with it, by the medium of the union of the several branches of the fifth pair of nerves in the medulla oblongata.

On the occurrence of Leucine and Tyrosine in the Pancreatic Fluid and contents of the Intestine. By Professor Kölliker, *Wurzburg.*

Professor Kölliker communicated the result of observations recently made by Professor H. Müller and himself on the normal occurrence of Leucine in the animal organism. This nitrogenous compound, which was first obtained by decomposition of various animal substances by strong chemical reagents, has been detected by Robin and Verdeuil in the lungs. Afterwards Frerichs and Stædeler found the same substance in diseased liver, and Virchow showed that it occurs normally in large quantity in the substance of the pancreas and of the spleen; in which latter organ it had first been found by Scherer and described as Lienin. This substance was discovered by the authors of the communication in the pancreatic juice of a dog, in which a fistula of the pancreatic duct had been experimentally established. It was also discovered by them in the contents of the duodenum and small intestine, but not in the colon, of man, dogs, cats, guinea-pigs, but not in the rabbit. It may be proper to notice that the guinea-pigs employed in these observations were fed on milk.

The leucine was obtained either by simple evaporation of the fluids, or by extraction by means of water. It presented under the microscope a spherical form, the single spheres being often marked with concentric lines, and were found isolated or aggregated in large spherical masses, or united in a laminated shape.

Together with these corpuscles were always to be found acicular crystals forming brownish spheres or dumb-bell shaped bodies, resembling those which Robin and Verdeuil have described as leucine. Stædeler and Frerichs seem to be of opinion that these bodies are tyrosine. In regard to this question, the authors observe that the chemical reactions of the two kinds of corpuscles referred to are not identical, the crystals not being so easily soluble in water and alcohol as the spherical bodies, but they do not venture to decide whether this depends on the leucine being mixed or combined with other substances.

On the Physiology of the Spermatozoa. *By* Professor Kölliker, *of Wurzburg.*

The first part of this paper treated of the effects of various reagents on the vitality and movements of the spermatozoa. From a great many observations and experiments on the effects of water, and various aqueous and other solutions of salts, acids, alkalies, in different substances, such as sugar, gum, albumen, urea, and many others, it appeared that a certain degree of concentration of these solutions is favourable to the maintenance of the motion of the spermatozoa, and that other degrees, either too low or too high, are hurtful. It was also ascertained that the spermatozoa might be revivified, or their motion restored by solutions of a certain degree of concentration bearing a fixed relation to that in which the motions had been lost, or when it had ceased from merely keeping the sperm; and that the caustic alkalies, soda, potash, and ammonia (not lime or baryta) have a special action in maintaining and restoring the motions of the spermatozoa. And it was further observed, by a series of comparative experiments, that while the action of different solutions on the spermatozoa is nearly similar in the several classes of Mammals, Birds, Amphibia, and Fishes, there is an appropriate degree of concentration of the solutions and reagents specially adapted to the maintenance of the motions of the spermatozoa in the animals belonging to each class.

From the very numerous facts detailed, the author deduced the conclusion, that the movements of the spermatozoa do not depend on mere endosmosis and exosmosis, but ought to be regarded as a truly vital phænomenon, or one depending on vital conditions, and which may be considered as belonging to the same class with, or bearing an analogy to the movements of cilia and those of the muscular parts.

With reference to the analogy between the phænomena presented by the seminal filaments and the motions of cilia and infusoria, Professor Kölliker found, by a series of observations on several of these structures, that there is a very great analogy in the action of different solutions on them and that which he had previously ascertained in the spermatozoa.

The author gave, in another part of the paper, comparative analyses of the sperm of different animals. In the sperm of the Bull, he has discovered the fatty principle named Myeline by Virchow, analogous to the phosphuretted fatty matters occurring in the brain, and the same as that discovered by Gobley in the sperm of the Carp-fish.

Professor Kölliker also called attention to the remarkable resistance of the spermatozoa to destruction by different chemical reagents, even of considerable strength, such as organic and mineral acids, and caustic alkalies, as bearing upon the question of the changes which these filaments undergo in the ovum subsequent to fecundation.

The second part of Professor Kölliker's paper related to the development of the spermatic bodies of the higher Vertebrata. From a series of observations recently instituted by him, it appeared that within the spermatic cells nuclei are contained in variable numbers, from one or a few up to twenty or more. Out of each of these nuclei one spermatozoon takes its origin by the conversion of the whole nucleus into the body part of the spermatozoon, while the filament is developed by the gradual elongation or extension of one side or pole of the nucleus. The spermatozoa, after they have assumed the filamentary shape, are still contained for a time in the spermatic cells, coiled up in a spiral form. They afterwards escape by the perforation or laceration of the cell-walls.

These observations lead to some modification of the description of this process of development previously given by the author.

Demonstration of the Trichomonas vaginalis *of* Donné. *By* Professor Kölliker, *of Wurzburg.*

Professor Kölliker exhibited to the Section, with the microscope, from specimens of vaginal mucus which were furnished by Dr. Tannahill from the Lock Hospital, the *Trichomonas vaginalis* discovered by Donné many years ago, but since only

observed by a few, and supposed by most to be a modified form of ciliated epithelium. Observations made in the present year by Professors Scanzoni and Kölliker show that the opinion of Donné is correct, and that this body is really an infusorial animalcule. It occurs in most specimens of vaginal mucus, containing mucous or pus-corpuscles, but is not a specific indication of syphilis.

Professor Kölliker showed at the same time, parasitic vegetable productions in the same mucus, which bore a close resemblance to the Alga occurring in the mouth, named by Robin *Leptothrix buccalis*.

A detailed description of these observations will appear in Scanzoni's 'Beitragen,' &c.

On a peculiar structure lately discovered in the Epithelial Cells of the Small Intestines, together with some observations on the absorption of Fat into the system. By Professor Kölliker, *Wurzburg.*

The following are the principal results of these observations :—

1. The cylindrical epithelium-cells of the small intestine of Mammalia, Birds and Amphibia, present at their extremities, directed towards the intestinal cavity, a thickened wall, in which, under favourable conditions, and with a good microscope, a distinct fine striation is to be observed; and which, though with greater difficulty, and almost only in the rabbit with certainty, is to be perceived from above as a fine punctuation.

2. This thickened striated cell-wall, which is also easily to be seen in isolated cells, swells up in water or thin solutions to more than double its natural thickness; the striation becomes remarkably distinct, and passes as if into separate filaments or fibrillæ, so as to give the cell the appearance of being ciliated. At last water destroys the whole border from without inwards, the inner part resisting longest. Water also induces two other changes in the intestinal cells; first, it causes the exudation from the uninjured cell of clear mucous drops, which have been erroneously represented as dilated cells; and second, it often removes the thickened membrane entirely. It is easy to distinguish, however, these two changes.

3. In herbivorous mammalia the thickened striated wall is wanting in the cells of the large intestine, and so it is also in Amphibia and Birds; but in carnivorous mammalia and in man there is observed a slight indication of it. In the stomach, the membranes of the cylindrical cells are without any peculiar structure.

4. In mammalia, fat becomes converted, previous to absorption, into immeasurably fine molecules, and passes as such into the epithelial cells. The larger fat-globules, which are seen, in particular conditions, in perfectly fresh cells, do not necessarily prove that the fat has entered in that form.

5. In all animals, and in all portions of the intestine, there are found between the common epithelial cells, other bodies of a granular structure, more club-shaped, and generally without distinct nuclei, which are to be regarded as cells seen in the act of regeneration, and burst at the upper end.

From these facts, the following views and hypotheses are suggested :—

1. The striæ in the thickened cell membrane may be pores or porous canals.

2. If this supposition is right, it follows that we may regard these canals as holding a direct relation to the absorption of fat; but it is also possible that they may have a more general signification, more especially in connexion with the taking in and giving out of materials by means of cells. In favour of the first view, it may be remarked,—*a*. That in many animals (herbivorous mammalia, amphibia, and birds in part) the thickened cell membranes exist only on the surface of the small intestine, while they are wanting in the glands, and in the large intestine and stomach. *b*. That cylindrical and ciliated epithelium of other localities presents nothing of any structure which would indicate the existence of the porous canals. *c*. That fat is absorbed in such fine molecules, that it is at least possible for these to pass through the porous canals.

The only fact which (always on the supposition that true porous canals exist) is opposed to the supposition now stated, is this, that in carnivora and in man the striated cell membrane is also found in the cells of the large intestine; but this fact

might appear to have no validity against the hypothesis, if it were shown that in these animals, in which the intestinal canal is short and the food rich in fat, the large intestine may also be the seat of the absorption of fat.

In reference to the porous canals mentioned above, the author wishes to explain that the porous structure now described by him in the intestinal epithelium cells is by no means the same as the pores of the epithelium alleged to exist by Keber in his work entitled "Microscopic Researches on the Porosity of Bodies." Königsberg, 1854. (See p. 38.)

On the Hectocotylus, *or Male of the Argonaut. By* Professor Kölliker, *of Wurzburg.*

Professor Kölliker exhibited specimens of the *Hectocotylus Argonautæ*, and of the entire male of the same animal, from the coast of Sicily. The author referred to the history of the progress of discovery with regard to the *Hectocotylus* of the Cephalopoda; the opinion of its parasitic nature adopted by Cuvier on its first discovery; Professor Kölliker's own observations in 1842 (published in 1845), which showed that the *Hectocotylus* itself must necessarily belong to the Cephalopods, and played the part of a male; the observations of H. Müller, who was so fortunate as to find the whole male, and thus to point out that the *Hectocotylus* is a peculiar and highly developed arm, destined for the purpose of fecundation; and to the observations of C. Vogt made shortly afterwards on the *Octopus Carena*. Specimens were exhibited, showing the various stages of development of the fecundating arm or *Hectocotylus* attached, and enclosed in its sac, on the male, and also in the detached state, which the author explained to the Section.

On the Form and Dimensions of the Human Body, as ascertained by a Universal Measurer or Andrometer. By James Macdonald. *Communicated by* Professor William Macdonald, *M.D., St. Andrew's.*

Mr. Macdonald exhibited the use of this instrument, and in a paper accompanied by elaborate tables, he stated the results at which he had arrived from a vast number of measurements as to the average proportions of the human body and its parts in adult life, and at different ages, and pointed out the various important uses to which a more accurate determination of these proportions may be applied in the public service and otherwise.

The average height of adult men in Scotland was found to be 67 inches, the head and neck $10\frac{1}{2}$ inches, the head and trunk 25 inches, the lower limbs from the division of the body or fork $31\frac{1}{2}$ inches. The average circumference of the chest is 36 inches, and that of the hips nearly the same.

The feet have attained their full length at 16 years of age, the legs at 18, but the trunk not till 25 years. The girth of the hips attains its full size soon after 18; that of the chest continues to increase for several years later, or nearly up to 25 years of age.

In the transverse section of a well-formed body, the arms are placed midway between the front and back, and occupy each about one-sixth of the circumference. In this case the section is oval or elliptical. When it is more nearly circular, the arms are set more backwards; when the chest is flat the arms are set more forwards.

Mr. Macdonald pointed out the relation between the various differences in these proportions and the capacity of the individual for different kinds of exertion, as in walking, running, leaping, the use of firearms, &c.

The following table presents in round numbers (or without the smallest fractions), the general result of the measurements of 144 adult men taken promiscuously from 804. The numbers express English inches and their parts. Each line gives the average of twelve individuals of the stature within the limits stated in the first column.

	Whole height.	Head and Neck.	Body.	Fork.
From	$52\frac{1}{2}$ to $63\frac{1}{2}$	$9\frac{1}{2}$	$24\frac{3}{4}$	$29\frac{1}{6}$
	64 65	$9\frac{3}{4}$	$24\frac{1}{2}$	$29\frac{3}{4}$
	65 $65\frac{3}{4}$	10	$24\frac{3}{4}$	$30\frac{1}{2}$
	66 $66\frac{1}{2}$	$10\frac{1}{4}$	$24\frac{1}{3}$	$31\frac{1}{2}$
	67 68	$10\frac{1}{4}$	25	32
	68 69	$10\frac{1}{4}$	25 nearly	$33\frac{1}{2}$
	69 $69\frac{3}{4}$	$10\frac{1}{2}$	$25\frac{1}{2}$	33
	70 71	$10\frac{3}{4}$	$25\frac{1}{2}$	34
	71 $71\frac{1}{2}$	11	$26\frac{1}{3}$	34
	72 73	11 nearly	$26\frac{1}{4}$	35
	73 $73\frac{3}{4}$	10^3	$26\frac{1}{3}$	$35\frac{3}{4}$
	74 79	$10\frac{3}{4}$	$27\frac{1}{3}$	$36\frac{1}{2}$
General average	$67\frac{1}{2}$	$10\frac{1}{2}$	25	32

On the Vertebral Homologies in Animals.
By Professor WILLIAM MACDONALD, *M.D., St. Andrew's.*

When Goethe and Oken first pointed out the striking analogy subsisting between the separate bony segments of the cranium of a deer which was accidentally picked up in the Black Forest, and the different portions of the vertebral column, they evidently adopted the usual definition of the vertebra, as then and still too commonly followed in the medico-anatomical schools, as consisting of a body—transverse and articulating processes with a bony ring terminating in a spinous process. The prevailing expression in common language of the whole vertebral column being viewed as *the back-bone,* long tended to obscure the investigation, and to some extent it still impedes the adoption of more scientific and philosophic views. This was strongly urged at the Association meeting at Cambridge in 1845.

If a simpler definition of a Vertebra were adopted, there is little doubt that the homologies of the bony segments of the vertebral column would be easily traced by the anatomical student and comparative anatomist, and with that view it is proposed to restrict the term vertebra, and thus define it to consist merely of the *Body* or *Centrum* with the *Transverse Process* or Diapophysis and the Mesapophysis. Thus restricted, it will form a portion or segment of the *Central Stem* on which the other laminæ are developed, and the skeleton constructed. On this ground the Professor repudiates the common appellation of the *back-bone,* and also on the ground of its consisting of many separable segments, each consisting of several bones.

First, the Central Stem or Caulon, in man, consists of several classes of bones or vertebræ, and extends from the *nasal spine* of the frontal bone, along the *basis cranii,* down the bodies of the vertebral column and sacrum to the simple condition in the coccyx.

In the lower animals, where the tail exists, the caulon is extended to the tip.

It is necessary to explain a few of the terms used in the present communication in order that the subject may be understood as intended. Lamina includes all the *bony branches* extending around the great cavities of the body arising from the caulon or *central stem,* viz. the ribs, bones of the face, as well as the limb-bearing zones, whether these support the maxillæ, the arm or the leg; also the perineural arches forming the tunnel for the cerebro-spinal axis. Following the example of the distinguished Hunterian Professor of the Royal College of Surgeons, Professor Owen, Dr. Macdonald feels inclined to adopt the Greek etymology in constructing the form of the nomenclature; but as it may be viewed as too pedantic, he also uses the names already adopted by others, and also such as can be made up of the common expression.

The chest and sacs	The CAULON or Central Stem or Vertebral Column.	Cerebro-spinal tunnel.
PROSOPO-KIST. Face chest, the mandible, incisive and palate-bones.		PROCRANIUM. Ethmoid and frontal bone.
		MESOCRANIUM. The sphenoid.
TRACHELO-SAC. Pharynx and larynx.		METACRANIUM. Parietal, petrosal and Wormial bones.
OTO-SAC. Ear apparatus. Hearing.		PARACRANIUM. Occipital bone below the tentorium.
The Throat.		HYPO-CRANIUM. Atlas and axis, and the four cervical vertebræ.
PNEUMO-KIST. Lung chest, the seven ribs and sternum containing the lungs and heart.		Upper dorsal. 7 and 14 vertebræ inclusive.
KOILO-SAC. Bowel-sac.		Lower dorsal. 15 and 19 vertebræ, 20 and 24 ,, } inclusive.
AIDOIO-KIST. Pelvis. The pelvic viscera.		Sacral. Coccygeal and caudal.

Connected with, and binding, as it were, the trunk or body, there are next to be described three limb-bearing zones.

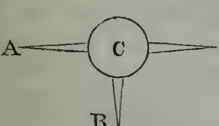
I. SQUAMO-ZYGOMATIC, or temporal bone (except the petro-styloid), supporting the maxilla or masticatory limb.

II. SCAPULO-CLAVICULAR, supporting the arm or respiratory limb.

III. COXAL, supporting the leg.

These zones have a general likeness in their functional connexion with the limbs or member I. and II., having glenoid cavities for the head of the membral laminæ, while the third generally has a well-formed acetabulum for the head of the femur, which affords a very important and useful test in the analysis of the homologues, especially in the class Ichthyia.

The ideal vertebra adopted is much simpler than either that of Owen, Geoffroy St. Hilaire, or Carus.



A. Diapophysis or transverse.
B. Mesapophysis.
C. Centrum, or body of vertebra.

The perineural laminæ consist of three portions or parts, but consolidated.

I. PRIMAL. The pedicle.

II. DIMAL. The lamella.

III. TRIMAL. The spine.

By the union of these the ring or perineural tunnel is formed. In like manner the perisplanchnic laminæ form the several chests, enclosing the visceral tubes and organs.

By thus separating from the ideal vertebra, the perineural and perisplanchnic parts, the zones and membral laminæ, the homology of the different parts of the skeleton can be more readily traced, and thus the beneficial application of homology

more widely extended, to the great advantage of the student. This is especially applicable in the homology of the osseous fishes, where, it is conceived, Professor Owen has misapprehended the homology of the limb, functionally as well as structurally.

When the British Association first met in Glasgow, 1840, the author submitted a scheme of the homology of the Cod and Haddock, demonstrating the pectoral fin as the homologue of the hind-leg, and not the arm, as proposed by Professor Owen; and also that the round head of the femur was received into an acetabulum of a coxa, which was connected with the cranium; and also, that what Cuvier and others had described as the scapula and clavicle, was really the femur and tibia, and that the fibula, from being inside of the reversed leg, was described as a new bony segment—epicoracoid; the foot was then described as the arm, forearm, carpus and hand, thus making two bones into the scapula, and multiplying one into several. A careful study of the skeleton of the human foot would very readily have shown the analogy which the tarsus bears to the bones of the arm; the astragalus = brachium, calcis = ulna, scaphoid = the radius, the cuneiform and cuboid = the carpus. The phalanges of the toes and fingers are easily seen to be identical. Functionally, the hind-limb in the Vertebrata is more or less associated with the sexual system; in the osseous fishes the pubis is widely separated from the pelvis, and is really homotypical of the sternum. It there is represented by the ventral fins. It appears in the Cetacea in a similar relation, also connected with the sexual organs.

It may be asked, where then is the homologue of the arm? this is easily seen in the opercular bones, which are here also connected with the respiratory system of the osseous fishes. It is entirely different in the Chondria or cartilaginous fishes, where the opercular bones are more in accordance with the higher animal types of terrestrial animals as motor limbs, while the pectoral fins are sent further back, forming the claspers of the rays and sharks. In those singular fishes, the Lophidæ, there may be traced an approach to the limb-form of the opercular bone, by the partial development of some fin-rays in the substance of the skin, but not protruding beyond its surface, at once forming the connecting link between the true osseous and cartilaginous fishes, which zoologically considered form separate and distinct classes. Geoffroy St. Hilaire was even further from the true homology of the opercular bones when he stated them to be the analogues of the auditory series, not perceiving that these are also arranged in accordance with the law of organic unity of plan, capable of modification by the necessities of each class of animals, and appearing in a vast variety of metamorphic types. The idea of Professor Owen, that the arm of man was merely the divergent apophysis of the occipital bone, is regarded as inconsistent with strict anatomy and function. All anatomists allow that the construction of the skeleton is regulated by and dependent upon the nervous system, whether in its original and primitive development in the fœtus, or in mature condition in the adult types. The skeleton has been described as the hard envelope protecting the neural axis and its primary branches; therefore the different limbs or members can only be connected with that part of the caulon from whence the nervous cords are emitted; in that view the arm has no connexion with the occiput, but with the lower part of the cervical and upper dorsal regions, through which the nerves forming the brachial plexus are transmitted. The same holds true with regard to the other membranal laminæ, and also the primary costal laminæ; and it is interesting to notice how strikingly this is demonstrable in the parietes of the chest, where the intercostal nerve passes out from the cerebro-spinal axis under the protecting rib, till it emerges in the region of the lower ribs near the distal part of the dimal portion, to be distributed on the upper abdominal parietes in a manner similar to the distribution of the nerves of the arm emerging from the interosseous space to supply the hand.

The true homology may be claimed as a *quæstio vexata* among anatomists; but if a careful examination of a vertebral skeleton in connexion with the distribution of the nerves be patiently conducted, there is little doubt that the scheme now submitted will be found not only the most simple and easy of application, but also most consistent with the structure of the vertebral skeleton. Having for twenty years steadily examined the subject, and being completely satisfied with the correctness of the explanation, the author cannot believe that the homology proposed by Cuvier,

Owen, &c., will any longer be adopted. He rejects the idea of the arm being the divergent appendage of the occipital bone, merely from being in the fish attached to the cranium as well as the coxal zone and leg; since in all the vertebral classes there is no connexion with the cranium and either of the anterior or posterior extremities; and whatever may be thought of calling the arm of man and higher mammals as the divergent appendage, it must be viewed as an error to describe the pelvis and leg as diverging from the occiput when placed at such an immense distance from the occiput, not only in saurian reptiles of the ancient world, but also the long-necked birds of the existing epoch.

As the complicated form of the ideal typical vertebræ, associated with the long Greek names not attended with the characteristic euphony of that ancient tongue has retarded in a great measure the study of homology, the author trusts the simpler formulæ now proposed will be examined and tested with the vertebral skeleton, as he believes them applicable to all forms.

A short Demonstration of the Origin of Tubercular Consumption. By Dr. M'Cormac.

Further Observations on the Fecundation of the Ova in Ascaris mystax. *By* Dr. Henry Nelson.

Professor Allen Thomson communicated observations from Dr. Henry Nelson, tending to confirm the views he had laid before the Royal Society, in 1851, on the process of fecundation in the *Ascaris mystax*. Dr. Nelson regarded it as certain that there is no vitelline or other enclosing membrane in these ova at the time when they meet with the spermatozoa; and he feels equally convinced of the penetration of the spermatozoa into the substance of the yolk, by which he means impactment or involvement. He further stated, that he had traced the gradual disappearance of the spermatic bodies after they had undergone changes of form, and had gradually become more and more intimately combined with the vitelline substance. He regarded these phænomena as evidence of a mutual action having taken place between the spermatic and vitelline substance, having the effect of producing a solution or peculiar disintegration of the latter. To take a coarse comparison, the author said that the involvement of the spermatozoa by the uncovered yolk might be likened to what would happen if a ball of snow were rolled over small masses of salt, and the whole were then enclosed in a bladder, which might represent the membrane which is formed only after impregnation has taken place.

Further Observations on the Structure of the Ova of Fishes, with especial reference to the Micropyle, and the Phænomena of their fecundation. By Dr. W. H. Ransom, *Nottingham*.

Dr. Ransom communicated the results of observations on the structure and impregnation of the ovum in fishes, and on the first changes which the yolk undergoes after fecundation. Dr. Ransom announced the existence of an aperture through the yolk-sac of the ovum, in several freshwater fishes; pointed out its relation to the formative yolk, and its importance as permitting the entrance of the spermatozoa. Dr. Ransom described certain peculiar contractions and rotations of the yolk which are among the earliest of the changes which follow fecundation, but which he believes to be due to the action of water upon a delicate membrane within the yolk-sac, and independent of the agency of the spermatozoon.

On the Mode of Action of Galvanic Stimuli, directly applied to the Muscles. By Professor Remak, *Berlin. Communicated by* Professor Kölliker.

Professor Kölliker presented on the part of Dr. Remak, of the University of Berlin, a short printed paper, of date 8th August, 1855, giving an account of experiments made during the past summer, with a view to determine in what manner various

muscles of the body are affected by the local application of electrical or galvanic currents over their surface. These experiments were undertaken chiefly with the view of ascertaining the accuracy of the statements contained in the recent work of M. Duchenne of Boulogne (de l'électrisation localisée, Paris, 1855), viz. that the local application of electricity shows that the muscles or parts of them are excited to contraction by the stimulus directly, and not through the intervention of their nerves.

Dr. Remak's experiments have led him to a different conclusion, viz. that the contraction of muscles produced by the application of the electric conductors in their vicinity is always the more powerful the nearer one of these conductors is brought to the place at which the principal nerve enters the muscle; and that the more limited contractions produced by the application of the conductors on the skin over the surface of subcutaneous muscles are not less the result of the distributed twigs of nerves in the muscular fibres. It is also an interesting result of these experiments, that the most efficient application of the stimulus is also the least painful, by directing the galvanic current towards the muscle, and carrying it away from the sensitive nerves which may be placed in the vicinity.

On the Antrum Pylori in Man and Animals. *By* Professor Retzius, *Stockholm.*

The author remarked that the name of Antrum pylori was first used by Willis in his work, "Pharmaceutices rationalis, sive diatriba de medicamentorum operationibus," &c. Few after him have appreciated the true form and importance of this part, except Cruveilhier. Professor Retzius has found three different forms of this part in man; he calls the one (described by Cruveilhier) the *short* form, the other (mentioned by Willis) the *long*, and the third he calls the *conical* form. In the first form the part has two ampullæ on the upper side, and one, sometimes two, on the lower, besides the great pyloric curvature (Coude de l'estomac of Cruveilhier). The two ampullæ nearest the pylorus are the most constant, and form a proper division of the whole antrum part. This has commonly a darker colour than the rest. In the second form, which Professor Retzius has often found in middle-aged females who had lived sparingly, the antrum is much elongated, tubular, and sigmoid, and is separated from the rest of the stomach as a quite distinct part, so as sometimes to have been mistaken for a part of the duodenum. The ampullæ are in this form not so much elongated, and not distinct, as in the other two; and the constrictions are very slight, and lengthened out. In the third form the ampullæ are small, less limited, and the whole part short, and nearly in the form of a truncated cone. In this form the "Coude de l'estomac" is very prominent, and the opposite plica in the lesser curvature narrow.

In all these forms, and most in the first, two proper bands of longitudinal fibres, partly muscular, partly of white and yellow fibrous tissue, run along both the anterior and posterior walls of the stomach. These bands are mentioned by several of the older anatomists as the bands or ligaments of the pylorus. As in the colon, these longitudinal bands are shorter than the tube, which is somewhat contracted by them; and by this shortening, as in the colon, folds and haustra are formed, which have been called by Cruveilhier "les ampoules."

The peculiarities of the mucous membrane in the pyloric part of the stomach were already observed by Sir Everard Home. The muscular coat is very strong, principally formed by a thick layer of circular fibres, whose thickest part in the length of an inch occupies the space nearest the pylorus, corresponding to the two last ampullæ. In many specimens Professor Retzius has found the before-mentioned white tissue covering what were formerly called the ligamenta pylorica, shining and white like tendons. He considers them as in a rudimentary degree corresponding with the well-known tendons in the muscular stomach of the Crocodile and Birds. Professor Retzius has found the same tendon on the pyloric part of the stomach of dogs, and peculiarly developed in the Arctic Bear.

In the stomach of the Arctic Hare this tendon is nearly quadrangular. The antrum pylori in several carnivora is an elongated and narrow tubular, sometimes conical part of the stomach. In the Common Seal (*Phoca annellata*, Nils.), the antrum pylori is a long, oval, and narrow cavity, folded back on the rest of the

lesser curvature. The muscular wall is very thick, and the mucous membrane of a peculiar appearance. The valvula pylori is wanting in many animals, and is replaced by the strong and broad layer of circular muscular fibres in the antrum pylori near the beginning of the duodenum. In some animals a little groove exists in the great curvature of the antrum, behind the passage into the duodenum. The border of this forms a thick semilunar fold, somewhat resembling a part of the valvula pylori. Professor Retzius regards the third stomach in the ventricle of the Porpoise (*D. phocæna*) as the same with the antrum pylori. The fourth stomach, which Cuvier describes, in the ventricle of *Delphinus*, is only a globular dilatation of the first part of the duodenum, in which part the biliary duct opens. Professor Retzius has found a corresponding dilatation in the first part of the duodenum in man and several mammals, and proposes to call it *antrum* or *atrium duodeni*. In man, the first part of the duodenum has no plicæ conniventes, as several anatomists have long ago remarked (Quain, Hyrtl). The author illustrated this communication with a rich collection of drawings.

On the peculiar development of the Vermis Cerebelli in the Albatros (Diomedea exulans). *By* Professor Retzius, *Stockholm*.

Dr. John Kinberg, Zoologist and first Surgeon of His Majesty's frigate 'Eugénie,' during her voyage in the Pacific Ocean, had occasion to prepare a perfectly fresh brain of an Albatros. The brain was immediately put in strong spirit, brought home, and presented to the Anatomical Museum of the Royal Caroline Institute. Prof. Retzius had remarked that the cerebellum of this specimen presented quite a peculiar development. It was flattened on both sides, with very little protuberance at the base of each side, and, as in birds in general, the central part or vermis much developed, but in this more than in any other known bird's encephalon. This middle part, forming the whole cerebellum, projects like a fan behind both hemispheres over the medulla oblongata, being more than one-third raised over the level of the highest points of the hemispheres. Professor Retzius counted on the edge twenty-eight tongues or foliated gyri, proceeding from two branches, one of which turns forward and the other backwards; the whole having some likeness to a cock's comb. Professor Retzius had examined the brains of many birds, but never found anything like this, and supposed that this peculiar development of the middle part might stand in some proper relation to the great perfection of the flight of the Albatros. This bird lives, as we know, only in the vast ocean; dividing his solitary life between the air and the waves, without approaching the shores by many miles' distance. Mariners meet with him in these regions, accompanying the ships for whole days without ever resting on the waves, and often without any visible movement of his large and powerful wings. And if it be as Professor Flourens regards it, one of the functions of the cerebellum to assist in the combination of the action of the separate muscles for motion, this combination must be so much more necessary the more perfect are the movements. In this bird, the strong, continuous, tranquil flight seems to occur in its highest degree, and, as Professor Retzius believes, depends on the peculiar development of the Vermis cerebelli.

On the Fornix Cerebri in Man, Mammals, and other Vertebrata. By Professor Retzius, *Stockholm*.

The shape of the fornix in the completely formed human brain gives us only an imperfect idea of the proper nature of this part. Professor Eschricht of Copenhagen has, in his excellent Manual of Physiology (Haandbog d. Physiologien), given an excellent description of the first formation of the fornix, as the inner and lower margin of the two original hemispherical vesicles, embracing the trunk or the arms of the cerebrum. This is the point of view from which the further development of this part ought to be considered. This view, of which we owe the first key to Tiedemann, had been adopted by Prof. Retzius in an original paper on the for-

mation of the hemispheres in the Transactions of the Royal Academy of Sciences of Stockholm for 1844, without his being then aware of Eschricht's views. Professor Retzius has in this view considered the fornix to form a part of the inferior surface of the hemispheres. (See his Treatise on Phrenology, considered from an anatomical point of view, 1847.) This is confirmed by examination of the brain in a great number of the mammals, in which the under surface of the fornix is to a considerable extent in its posterior part, covered with bilateral and symmetrical gyri of grey substance. In man these gyri are small and thin. The posterior part of them is situated under the lateral parts of the so-called splenium corporis callosi (which partly belongs to the fornix). Here these gyri are very pale, greyish, low, smooth, only 4 millimetres broad. The posterior ends, which are convergent, are small, tongue-shaped, and very thin; they diverge anteriorly in proceeding towards the cornua Ammonis, where they are continued as the well-known fascia dentata of the hippocampus or cornu. Professor R. mentions that these gyri are represented in Vicq d'Azyr's 20th table, especially in the coloured part on the left side. It seems that Vicq d'Azyr himself had not given any particular attention to these gyri, as they are not mentioned in the text or explanation of the plates. The author illustrated this paper with a number of drawings, representing the brains, in different stages of development, of mammals and man.

On an Episcaphoid Bone in both Hands of a Guarani Man. *By* Professor ANDREW RETZIUS, *of Stockholm.*

A Swedish gentleman, Signor Liljedahl, now mining engineer in Paraguay, sent home, some years ago, with the Swedish corvette 'Najaden,' from Buenos Ayres, a skeleton of a native man of the Guarani race. Among several other peculiarities in that skeleton, now belonging to the Anatomical Museum of the Royal Caroline Institute at Stockholm, it had nine carpal bones on both hands. The supernumerary bone was situated on the upper articular surface of the scaphoid bone, turned towards the vola, and near the lower end of the radius, and opposite the pisiform on the ulnar side. It bore much resemblance to a large pisiform bone; its articular surface was concave: on the outer side it had the appearance of a ligamentous connexion. It is probable that the proper annular ligament had had one of its attachments to it. Its length from above downwards is 13 millimetres, height from the articulating surface 11 millimetres, thickness 9 millimetres. The posterior side is flattened, with two small tubercles on the anterior surface. The other half was a part of the surface before mentioned for ligamentous attachment. The rest was concave, forming a slight groove. The bones in the two hands are precisely the same shape, and are nearly of the same size. Future observations will probably show whether such bones are of more or less frequent occurrence among the Guaranis. Dr. Retzius hopes he may obtain further information on the subject from his countrymen, Dr. Rosenskjold and Mr. Liljedahl, in Paraguay, to whom he had applied.

On the Pelvis of a Lapland Giantess. *By* Professor ANDREW RETZIUS, *of Stockholm.*

Professor Retzius exhibited a cast, and described the pelvis of a giant Lapland woman, aged 43 years, which, with the whole skeleton, he had obtained for the Museum of the Royal Caroline Institute of Stockholm. This woman was 6 feet 13½ inches (Swedish measure) in height. The pelvis presented a general enlargement corresponding with that of the rest of the body. It was nearly naturally formed, but approached somewhat the male form, more especially in the narrowness of the subpubic arch.

On the application of Physiological Principles to gymnastic education. *By* Dr. ROTH, *London.*

Some Observations on the Chemistry of Fœtal Life. By Professor SCHLOSSBERGER, *of Tubingen. Communicated by* Professor ALLEN THOMSON.

Having lately made some observations on the chemistry of the fœtus, hitherto a *terra incognita,* the author has obtained some remarkable results, of which the following is an abstract.

1st. I have analysed the milk of the uterus of Ruminantia, which is the best example of a fœtal food. I found microscopic corpuscles in it, resembling the first stages of the corpuscles of true milk. The secretion is acid (volatile fatty acid). It contains no sugar, little fat, and is very rich in proteine compounds. Therefore it seems that the fœtus in which the respiratory process is going on more slowly has a food in which the plastic nourishment prevails, the necessity for purely respiratory material being less than in the adult. The quantitative analysis gave in 100 parts the following proportions in the fœtus of a calf of six weeks :—

Water		88·07
Fixed solids		11·93, viz.
Fat	1·59	
Ashes	0·71	
Albumen and cells, &c.	9·6	
		100·00

A comparison with the colostrum and the true milk of the cow is suggested by this.

2nd. The stomach of the fœtal calf contains true mucine, described by Scherer. The viscous fluid contained in the stomach is precipitated by acetic acid, and the precipitate is not soluble in excess of acid.

I found quite marked differences between the contents of the stomach and amniotic fluid, so that both must be regarded as independent secretions. Nevertheless I will not deny that the fœtus occasionally swallows the amniotic fluid. As a proof of this I give the following analysis :—

Contents of the stomach of a fœtal calf twenty weeks old.

Water		98·6
Solids		1·4, viz.
Mucine	0·44	
Salts	0·96	
Organic substance precipitated by tannic acid	0·1	
		100·00

The amniotic fluid of the same fœtus contained in 100 parts—

Water	96·03
Organic substance	2·93
(no mucine.)	

3rd. The fourth stomach of the fœtal calf possesses in a high degree the coagulating action on milk.

4th. The amount of water contained in the fœtal organs is as follows :—

	Fœtus of 4 weeks.	F. of 6 weeks.	F. of 20 weeks.
Brain	91 per cent.	— per cent.	— per cent.
Heart	88 „	— „	— „
Lungs	90 „	90 „	86 „
Muscles	91 „	92 „	87 „
Liver	— „	83 „	83 „
Blood	— „	82 „	80 „

The general result of a considerable number of experiments has been, that many tissues of the fœtus are richer in water than the blood of the fœtus, and that the organs which contain the greatest amount of blood have the least water.

On the Use of the Round Ligament of the Head of the Femur. By Dr. JOHN STRUTHERS.

On the Use of the Round Ligament of the Hip-Joint.

By Dr. John Struthers, *F.R.C.S., Lecturer on Anatomy, Edinburgh.*

By removing the bottom of the acetabulum so as to expose the round ligament from behind, while its attachments and those of the capsular ligament are left entire, the author has been able to afford actual demonstration of the use of this important ligament. On moving the femur in the various directions, it is now seen that the ligament becomes quite tight only in rotation outwards. It approaches the tight condition in adduction,—the motion which this ligament has more recently been supposed to check, so as to support the body on the femur in the erect posture; but extreme adduction does not actually stretch the ligament. In rotation outwards, however, the ligament is so much stretched as to be flattened upon the bone, and is perfectly tight. It is not tightened in rotation inwards, as this is a more limited motion than rotation outwards. This being the fact, the reason seems to be, that it is in this motion, rotation outwards, that the femur is naturally most liable to, and would otherwise leave the socket. To prevent this there are two provisions,—the great thickness of the front half of the capsular ligament, and, internally, the round ligament. By adopting this method of demonstration, any anatomist may satisfy himself as to these statements. It must be granted that the ligament can be of use only in that position in which it becomes tight.

On the Explanation of the Crossed Influence of the Brain.

By Dr. John Struthers, *F.R.C.S., Lecturer on Anatomy, Edinburgh.*

The object of this paper was to show that the decussation of the anterior pyramids of the medulla oblongata affords only a partial explanation of the phænomena of crossed nervous influence. This was made evident by the want of proportion or correspondence between the phænomena and the amount of decussating matter, which does not include above one-third of even the cerebral portion of the medulla oblongata; while the influence of each side of the brain, as regards both motion and sensation, is usually entirely crossed upon the opposite side of the body, as seen in cases of palsy, putting aside in this argument the results of experiments on the lower animals. The statements as to exceptional cases in human pathology, are not unlikely to have had their origin in mistakes in the use of the terms right and left.

Further, we have evidence of the influence having crossed a considerable distance above the decussation of the pyramids, in the fact, which the author's own observation attested, that in cases of palsy of one side of the body, accompanied by palsy of the face, the two palsies were on the same side, and therefore on the opposite side to the cerebral lesion.

The conclusions drawn were—

1. That the influence of the brain is entirely crossed, one side of the body being set on the opposite side of the brain for both motion and sensation; unlike the optic decussation, which is a half decussation, serving a special purpose in the equal reflex regulation of the pupils.

2. That the phænomena could not therefore be explained unless by a complete decussation of each lateral half of the descending fibres of the brain.

3. That the decussation of the anterior pyramids does not form more than about a fourth part of the anatomical decussation or decussating channel.

4. That the situations in which the rest of the fibres passed, or might pass, across the middle line, are (*a*) the middle line of the pons, where especially the fibres of the great crus cerebelli may decussate, and thus readily explain the crossed influence of the cerebellum, which could not be well explained through the restiform body. (*b*) The middle line, or so-called septum, of the medulla oblongata. (*c*) The white commissure of the spinal cord in its whole length. In these situations there is no coarse decussation like that of the pyramids, but ample space for a complete decussation, by a finer admixture of the whole of the descending fibres of the brain.

On the Muscles of the Extremities of Birds.

By Professor CARL J. SUNDEVALD. *Communicated by* Professor RETZIUS.

This paper contained an abstract of an extended examination of the comparative anatomy of the muscles of the limbs in the various orders and families of birds in further elucidation of views brought forward by the author in 1851, together with an attempt to determine the homologies of these muscles with those of mammals and reptiles. The author traced to variations in the skeleton many of those differences in the muscles which had occasioned so much difficulty to comparative anatomists in ascertaining their homologies. He remarks on the inappropriateness of many of the names applied to the muscles from human anatomy, such as triceps and biceps brachii, &c. The biceps he would call Vector brachii, and for the Biceps femoris, he would propose the name of Pulsator in connexion with its action on the foot. The posterior clavicular bone of birds, usually named coracoid by recent anatomists, he would propose to call obex (bolt or bar), as the coracoid is in reality only a part of this bone; and he would distinguish thus the muscles which are attached to the whole bone as obical in distinction from those which are simply coracoid.

The subclavius muscle of birds the author regards as merely an anterior part of the pectoralis minor, and he adduces in proof of this view the variations of this muscle in different mammals, more particularly those wanting the clavicle, in which the subclavius is proportionally large and is continued on to the humerus along with the pectoralis minor.

The greater part of the cervical muscles going to the shoulder is wanting in birds, such as the sterno-mastoid, omo-hyoid, &c. The muscle usually termed cucullaris in birds is only an extension of the upper rhomboid, being covered by the latissimus, and the fore-part of the latissimus corresponds to the dorsal portion of the true cucullaris. The so-called pectoralis tertius (of Tiedemann), or coraco-brachialis inferior (of Meckel), is a part of the coraco-brachial modified as in Saurians by the extension of the coracoid bone.

The large pelvic muscle of birds which extends over the patella to the tendons of the perforated flexors, and has been variously considered as rectus femoris, pectineus or gracilis, is called by Sundevald musculus ambiens. It is not, as has been generally supposed, the means of enabling birds to sleep sitting on the branches of trees, &c., as it is frequently wanting precisely in those birds which have this habit, and is found, but not invariably, in the Swimmers and Waders.

The femoro-caudal muscle is a small representative of the muscle which is so very large in Saurians, and which gives the backward direction to the hind-limbs. The author leaves it doubtful, whether it is, as has been supposed, the pyriformis with a more extended attachment to the vertebral column.

On the whole, the muscular system of different families of birds presents very considerable varieties. The singing birds (Oscines, part of Passeres) have the greatest uniformity. They are distinguished principally by the large size and extent of the deltoid and the breadth of the teres minor. They have no gluteus maximus and no ambiens, and the femoro-caudalis is simple. Sundevald points out, that the Menura, Tyranni and Furnarii, and some other birds of doubtful systematic place, have the same muscular structure as the Oscines, and should be placed under the same division with them (as he proposed in 1835), but perhaps under a separate section, as they do not possess the singing apparatus.

In a number of the Scansores the gluteus maximus is wanting; the ambiens and femoro-caudalis variable; the peronei deficient or very short, as also is the case in Colymbus and Podiceps.

The Raptatores have no semitendinosus and no tibialis posticus, but they possess a small gluteus maximus. In Falco and Vultur the ambiens exists, but not in owls. It is interesting that all the muscular peculiarities of the diurnal birds of prey are found in Tachypetes, proving their close relation.

In the Gallinæ, Grallæ and Anseres, the accessory head of the tensor præalaris is small. In most of them, the gluteus maximus is present, but very small. The Gallinæ are especially distinguished by their large subclavius, separate from the pectoralis minor, by the humero-ulnaris internus peculiar to them, and by their large pronators. In Wading birds there is little peculiar. The Swimming birds are

distinguished by a peculiar form of the semitendinosus, which is similar to that of mammals.

The ostrich shows some of the greatest peculiarities in the form of the sternal and clavicular muscles in connexion with the modifications of the bones. There is no femoro-caudalis, tibialis posticus, nor peroneus brevis. The most remarkable peculiarity is in the existence of the second head of the vastus internus, which is like a gracilis muscle, which indeed it has been called. This is also the case in the Cassowary and Apteryx. In all other birds the gracilis is quite lost.

The Gallinæ have the greatest number of muscles present among birds; the Podiceps (Natatores) the fewest, wanting the ambiens, femoro-caudal, semimembranosus, gluteus maximus, flexor arctic. prim. digit. secundi, peroneus brevis, digital tendon of peroneus longus, the femoral head of the semitendinosus, and the gastrocnemius medius.

On the Formation and Structure of the Spermatozoa in Ascaris mystax. *By* Professor ALLEN THOMSON, *M.D., F.R.S.*

This paper contained an account of observations instituted by the author, with the view of ascertaining the validity of the objections raised by Professor Bischoff of Munich to the views of Dr. Henry Nelson on the subject of the fecundation of the ova of *Ascaris mystax*, and which were communicated by the author to the Royal Society in 1851. Professor Bischoff considered the bodies described by Dr. Nelson as spermatozoa to be nothing more than peculiar epithelial particles belonging to the female passages; but Professor Thomson has succeeded in showing in full detail the whole progress of development of the peculiar flask-shaped spermatic bodies which Dr. Nelson found in the female *Ascaris*, from their earliest stages in the male, and has thus proved satisfactorily their spermatic nature.

The following are the principal steps of the development of these spermatic bodies:—1st. They arise by cell-germs in the uppermost cæcal extremities of the male testicular tubes; which cell-germs are probably not formed singly, but by endogenous increase within parent-cells. 2nd. In the next part of the tube, which is opake or granular, each of these cell-germs is surrounded by a mass of fine granular matter, so as to constitute each an aggregated cell, at first without any external wall, but afterwards this wall is formed by deposit or change round the granular mass. 3rd. The granular nucleated sperm-cell is divided into four, and the granular matter of each portion assumes a remarkable appearance of radiated lines. These remain united together for a time. 4th. The four cells next separate from each other, the radiated linear appearance returns to the granular state, and each of these cells is the source of a spermatic corpuscle. 5th. In general the spermatic cells do not advance beyond this stage, so long as they remain within the male organs; but in some cases the author perceived transitions to the forms that are found in the female passages, and was thus enabled to prove the identity of the two sets of bodies. The formation of the spermatozoon from the last-mentioned cells took place by the clearing up of one part of the outer or granular part, and the removal of the granules to the other side; while the spermatozoon itself was produced by the thickening of the wall of the nucleus in the shape of a dome or hemisphere on one side of the nucleus, the open side of the dome being occupied by the remains of the granular matter and the nucleolus. 6th. In the female passages, the higher these spermatic cells have ascended, the more advanced are they found in the changes of the nucleus into the spermatic body, until in the upper part of the oviduct, where they first encounter the ova, and, according to Dr. Nelson, effect fecundation, they have attained their full development, and have assumed the peculiar flask or test-tube shape. In the lower parts of the female passage, every stage of transition, from the forms observed in the lower part of the vas deferens of the male, through the dome, bell, flask, and test-tube forms, is to be found.

The author pointed out the peculiarity of form and mode of development belonging to those spermatozoa which, as in the *Ascaris*, are acaudal and motionless. The highly refracting part of the spermatic cell, which assumes the dome or flask-shape, he regarded as corresponding with the body part of the spermatozoa in the higher

animals; but in the *Ascaris*, this part, in its growth, by thickening from the nucleus, never closes completely over it, but leaves one side as it were open, occupied by the remains of the granular covering and by the nucleolus. The development, accordingly, never reaches that stage, in which, as shown by Kölliker's most recent observations in the higher animals, the caudal filament is formed by prolongation from the closed nucleus. The want of motion in the spermatozoa of the *Ascaris*, the author considered to be dependent on the absence of the caudal filament, which, when present, acts precisely in the manner of a vibratile cilium.

The author entered into various details as to the particulars in which his observations agreed with or differed from those of Reichert, Nelson, Bischoff, and Meissner, on the same subject.

On the Brain of the Troglodytes niger. *By* Professor Allen Thomson, *M.D., F.R.S.*

As the brain of the Chimpanzee had been little investigated by anatomists, the author exhibited and described a dissection of it which he had recently had an opportunity of making. The specimen belonged to a female, which was probably of six or seven months old. The author called attention to the various points of resemblance and difference between the human brain and that of the Chimpanzee and other Simiæ. The communication was illustrated by photographic and other representations, and by dissections of the brains of various animals.

Contributions to the History of Fecundation in different Animals. By Professor Allen Thomson, *M.D., F.R.S.*

In this paper, the author first gave an account of a series of observations which he had made, confirmatory of Dr. Ransom's discovery of the micropyle aperture in the ovum of fishes, viz. in the salmon, trout, and stickleback, and the fact of the entrance of the spermatozoa within the membrane of the ovum.

The author next gave a detailed description of the development of the ovum in *Ascaris mystax*; and in connexion with the mode of its fecundation, adverted particularly to the fact, which he had placed beyond doubt, that at the time when the peculiar motionless spermatic bodies first meet with the ova in their descent through the female passages, and effect fecundation by the peculiar penetration observed by Dr. Nelson, the ova are destitute of any membranous covering; and the spermatozoa come, therefore, into direct contact with the exposed surface of the yolk. Professor Thomson's observations were, therefore, in support of the views of Dr. Nelson on this subject, and in opposition to those of Meissner, who conceives that, in *Ascaris* as in *Mermis*, the spermatozoa are introduced through a micropyle aperture in a membranous covering; and to those of Bischoff, who denies the spermatic nature of the bodies referred to.

Professor Thomson described an observation in which he had fully confirmed the statement originally made by Dr. Martin Barry, of the penetration of the spermatozoa into the mammiferous ovum, as has more recently also been observed by several continental physiologists. The author's observations were made on several ova taken from the Fallopian tube of a rabbit, about seventy hours after sexual intercourse, in all of which he detected very clearly a considerable number of spermatozoa within the zona, but without his being able to perceive any indication of an aperture or micropyle in that membrane.

The author next passed in review the various observations of recent authors with regard to the micropyle structure, and the phænomena of fecundation related to it, or independent of it, in different animals; more particularly those of J. Muller, Newport, Meissner, Keber, Leuckart, Leydig and others, and deduced some general conclusions therefrom as to the manner of the fecundating process. From these it appeared that the micropyle aperture, first discovered by J. Muller in *Holothuria*, is of frequent occurrence in the ova of animals; that it is not invariable, however, but that when present it is always related to fecundation; that in some animals it exists from the earliest condition of the ovum, while in others it is of

later formation; that future observations will probably bring it to light in many animals in which it is not yet known; but that in others it is most probably entirely absent; and yet, that spermatozoa penetrate the egg coverings, even though these are of considerable density, as in the case of mammalia; that it appears to exist principally in those ova of which the coverings have peculiar strength and density; that in a number of instances the spermatozoa meet with the ovum previous to the formation of any enclosing or vitelline membrane, and must thus act directly on the yolk or germ; and that in a few animals (as Trematode and Cestoid worms), the spermatozoa are mingled with the contents of the ovum, viz. germinal vesicle, and yolk substance, at the period of their being brought together in their formation, and are thus enclosed, along with the rest of the parts, by the membrane which is afterwards deposited externally.

Thus, while many interesting and important additions have been recently made to our knowledge of the history of the phenomena of fecundation, further observations are still required to bring these phænomena, as observed in different classes of animals, under one general doctrine or law.

GEOGRAPHY AND ETHNOLOGY.

Ethnology.

On some peculiar Circumstances connected with one of the Coins used on the West Coast of Africa. By the Rev. Thomas C. Archer.

Description of Timbuctoo, its Population, and Commerce. By Dr. Barth. *Communicated through the Foreign Office.*

Before reading the paper, Dr. Shaw informed the meeting that Dr. Barth had just arrived in London in safety. Dr. Barth, dating from Timbuctoo, on the 2nd of October, 1853, acquainted the Earl of Clarendon, the Foreign Minister, that on the 7th of the month previous he had reached Timbuctoo, and had met with a very satisfactory reception. He entered from the south side, having navigated a considerable channel of the river. He was escorted to the town from Kabara by Sidi Alawad, the brother of the absent Sheikh of Bakay, and welcomed by great part of the wealthier Arabs inhabiting the place; but was obliged to support before the people the character of a messenger of the Sultan of Stamboul, his real character being known only to his protector. When the Sheikh of Bakay himself arrived, he gave Dr. Barth the fullest assurance of his safety in the town, and his safe return home by way of Borno; he had done so before, and as far as his influence extended, had given "full security to any Englishman visiting this place." Dr. Barth then gives a brief description of the town:—"Timbuctoo is situated, according to an accurate computation of my route, 18° 3′ 30″ to 18° 4′ 5″ north latitude, and 1° 45′ west longitude, Greenwich; and is distant from the river itself further than has been supposed,—Kabara, its so-called port, being situated on a very small ditch, which, being inundated by the river, is made navigable for four, or, when the rains have been most plentiful, for five months in the year; whereas, during the eight remaining months, all the merchandise has to be transported on the backs of asses to a much greater distance than Kabara.......As for the town itself, it is not now environed by a wall, the former one having long ago fallen into decay; but like the small towns of the Tonray in general, its mud houses form a tolerably entire enclosure, pierced only by narrow entrances. Having been at least twice as large during the period when the Tonray empire was in its prime and glory, its circumference at present does not exceed two and a half miles. The whole town consists of houses built of mud, for the greater part only one story high, while the wealthier people have all their houses raised to two stories. There are at present only three mosques in the town. The

market is well supplied with rich merchandise, much better than the market of Kano. But there is a great defect in the scarcity of current coin,—salt, a rather heavy, unmanageable sort of money, being the standard for all larger things much more than gold, while cowries are extremely scarce, and dollars are scarcely accepted in payment by anybody. The population of Timbuctoo, as well as its government, are considerably mixed. The original, and by far the most numerous part of the inhabitants, are the *Tonray*, who, after the supremacy of Morocco had ceased, regained once more the government of their town, and were not disturbed by the Bambara, who *did not* obtain possession of Timbuctoo, though on the south side of the river their empire extended as far as Hombori. Besides the *Tonray*, there are the Arabs, partly settled, and partly belonging to different tribes of the desert, and remaining only for several months or years. Certainly, the mixed population of this place for itself is not able to repulse any serious attack, as it was taken twenty-eight years ago (one year before the unfortunate attempt of Major Laing) by the Fullan of Mohammed Lebbo, almost without a struggle." Referring to the Fullan of Hand Allahi, whom he was desirous of visiting, Dr. Barth says,—"Their fanaticism would, if not endanger greatly my situation when among them, at least make it all but intolerable; for these Fullan, who call their brethren of Tokoto 'infidels,' and have threatened them with teaching them Islamism, think themselves the only true Moslems. Amongst other things, they have made smoking a capital crime; so that even in Timbuctoo, except near the house of El Bakay, a man smoking is in greater danger than in the streets of Berlin."

On the different Centres of Civilization. By John Crawfurd.

The Manual of Ethnological Inquiry and the Ethnology of Polynesia. By Richard Cull, *Fellow and Honorary Secretary of the Ethnological Society.*

The two editions of the 'Ethnological Manual' issued at the expense of the British Association have been circulated far and wide. The second edition, with which I have had more to do, has been sent to every missionary station in the world, to many of our naval and military stations, to men of science and known ability in various countries, and to travellers. It has been thought that the results have not been in proportion to the expenditure, pecuniary and otherwise, of our two 'Manuals,' and accordingly it has been proposed to discontinue further outlay in the distribution of the remaining copies of the second edition. The collection of information, in accordance with special directions such as those contained in our 'Manual,' is necessarily slow. We can only request persons to observe and record their observations for the use of science. Still the 'Manual' has been of use in many ways. The late lamented Capt. Owen Stanley used it as his guide in his surveying expeditions, and I am informed by Mr. Brierly that it was constantly on the captain's table as a book of very frequent reference. Several officers both of the Royal Navy and of the Mercantile Marine have expressed themselves to me as deeply indebted to our little 'Manual' as a useful guide in observing man.

In the interval between the exhaustion of the first edition and the issue of the second, 'The Admiralty Manual of Scientific Inquiry' was published. Dr. Prichard contributed to this 'Manual' the Section on Ethnology, and avowedly drew largely upon our little 'Manual,' adding new matter, improving and adapting it for the special service of the Royal Navy.

In editing the second edition of our little 'Manual,' the Committee naturally availed themselves of Dr. Prichard's improvements, and I think we improved it still further.

The 'Admiralty Manual' has been published more than six years, but beyond the most interesting information collected by Capt. Collinson of the Western Esquimaux, I am unaware of any results from the Ethnological section of it. When we consider the great difficulty of observation, we ought not to feel disappointed at the seemingly inadequate results, and we ought to have patience in waiting for results, as I am about to show. I hold in my hand a copy of 'The Samoan Reporter,' a periodical

published half-yearly in the island of Samoa, consisting of one sheet filled with chiefly secular matter contributed by missionaries, each number containing a chapter on the Ethnology of the Pacific Islands. The missionaries of these islands were supplied with the first edition of our 'Manual,' and some of them at once appreciated its value as a guide to enable them to study the ethnology of the people they are labouring to convert to Christianity. It is now nearly ten years ago since the first article appeared on the Ethnology of these islanders printed on one of the islands. The ordinary work of the mission so fully employs the printing press of the station, that it is not found practicable to print the journal oftener than half-yearly. It was only in April of this year that I became aware of the existence of this periodical through the kindness of the Rev. E. Prout, the Home Secretary of the London Missionary Society. I have brought this to the notice of the Association through this Section as one gratifying result of the usefulness of our 'Manual.'

The frequent reference to our little 'Manual' by travellers and others ought to satisfy us that our labour has not been in vain. If the results of researches suggested and directed by that 'Manual' have not been published to the world through this Association, let us not indulge in selfish regrets, but rather rejoice that in any way it has contributed to the advancement of Ethnological science.

On some Water-colour Portraits of Natives of Van Diemen's Land. *By* Richard Cull, *Hon. Sec. Ethnol. Society.*

Mr. Cull exhibited a number of authentic portraits of natives of Van Diemen's Land, and remarked that the value of these portraits was enhanced by the circumstance that they could not be replaced, for not one of the aborigines was now alive, or, at any rate, not more than one. The chief object of the paper was to show that the aborigines of Van Diemen's Land were not black, as was popularly supposed, but of a brown complexion.

On the Complexion and Hair of the Ancient Egyptians. *By* Richard Cull, *Hon. Sec. Ethnol. Society.*

On the Forms of the Crania of the Ancient Romans. *By* Joseph Barnard Davis, *M.R.C.S. Engl., F.S.A.*

A numerous series of ancient Roman skulls, derived from three different sources in Italy and from Roman cemeteries at Eburacum, Londinium, Lindum and Glevum, has fallen into the hands of the author. As the basis of these observations, he selects the cranium of Theodorianus, a Roman of consequence, who died at Eburacum in his 35th year, and whose inscribed stone sarcophagus was discovered many years ago. The venerable antiquary of Roman York, the Rev. Charles Wellbeloved, has referred him to a Roman family of Nomentum, a town of the Sabini in Italy. His skull is an elegant example of the capacious Roman cranium. It is marked by the squareness of face common to the *typical* form of the Roman head, the fine prominent nasal bones of aquiline profile, their position being more expressed from the broad nasal processes of the superior maxillæ—the expanded and capacious forehead, of somewhat low elevation, terminating below in a prominence of the supra-nasal region, which distinguishes it from the regular skull of Grecian type. It may be regarded as belonging to the typical section of ancient Roman crania, although not presenting the typical character in so decided a form as others exhibited. It will come under the division of what may be called *platy-cephalic* crania, those distinguished by a horizontal expansion of the vertical region. The diacritical marks which distinguish the crania of the ancient Britons from those of the ancient Romans may be expressed as follows: after remarking that those of the Romans were decidedly the larger, he adds:—The face of the *former* was rather shorter, more irregular, deeply marked by muscular impressions, with a frowning supra-nasal and supra-orbital prominence; short but abruptly eminent nasal bones, rising suddenly out of the depression at the root of the nose; the forehead narrower, yet rising at about the same angle to nearly an equal elevation. The face of the *ancient Roman* was slightly longer, fully as wide in

all parts, and sensibly wider in the frontal region, and at the angles and condyles of the lower jaw. This increased breadth at the two extremities, with want of elevation of forehead, imparted to the countenance that quadrangular appearance so commonly observed in the statues of ancient Romans of Consular and Imperial times. The calvarium in the *typical* British skull is marked by particular shortness; that of the ancient Roman viewed vertically is not remarkable for shortness, whilst it preserves a considerable breadth. It is fully half an inch longer than the British, and yet somewhat wider. Commencing in the frontal region, this width extends to the temporal in all its parts, and to the parietal. It is on this feature we are disposed to rest its peculiarity, and to call it *platy-cephalic*, to express that especially expanded form belonging to it without marked loftiness. Probably ancient British and Roman skulls agree pretty closely in elevation. The well-known peculiarity in the nasal bones of the latter, mostly conjoined with remarkable breadth and elevation of the nasal process of the superior maxillary, is another typical mark.

The author next refers to two selected from several skulls obtained from burials on the Via Appia—to a series derived from the Roman cemetery without the south-western gate of Eburacum in 1852—to others obtained from the Roman Cemetery of Londinium in the Borough, dug up from the 'Roman level' about 16 feet below the present surface. He compares the physical characters of the ancient Romans with those which may still be observed in the modern population of Italy, and infers that "notwithstanding the vicissitudes of all the ages intervening between the present and imperial times, we have just ground for believing that the indicia of the ancient Roman people are still unextinguished in their descendants." He concludes by suggesting the inquiry into the degree in which these peculiarities of the Romans may be traced in the people of Britain.

On a Universal Alphabet with ordinary Letters for the use of Geographers, Ethnologists, &c. By ALEXANDER J. ELLIS, *B.A., F.C.P.S.*

The problem to be solved is, Given an ordinary fount of roman (or italic) letters, consisting of capitals, small capitals and small letters, with stops, but without accented letters (as these are seldom supplied in sufficient quantities), to write the sound of any word in any language with a correctness intelligible to a native. The solution should contain provision for the use of existing accented letters when feasible, and for a rougher approximation when sufficient.

In the following digraphic alphabet the first column contains the rough approximation, with the duplicate accented letter, the second its explanation, together with the finer approximations. Thus *a* may be used for G. m*a*nn, E. m*a*n, F. p*â*te, or these three sounds may be distinguished as *a*, *ae* or *ä*, and *aə* or *à*. Again, *aao* or *āo* or *ǫǫ* may represent the long sound of *ou* in n*ou*ght. Capitals are only used as initials.

Digraphic Alphabet arranged in the order of the Roman Alphabet.

E. English, G. German, F. French, I. Italian, S. Sanscrit, Sc. Sanscrit cerebral, A. Arabic, Ad. Arabic dental.

A a. G. m*a*nn (a); E. m*a*n (ae, ä); F. patte (aə, à).
aa (ā). E. f*a*ther (aa, ā); F. pâte (aaə, āə, àà).
ao (ǫ). E. not (ao, ǫ); I. rocco (oə, oa, ò).
aao (āo, ǫǫ). E. n*ou*ght; I. poco (ooə, ōə, ooa, ōa, òò).
ai. G. mein (ai), E. mine (əi).
aoi. E. ho*y* (aoi); G. *eu*le (aue, aü).
au. G. h*au*s (aü); E. h*ou*se (əu).
aa. F. ch*ant*.
B b. E. *b*e.
C c. Af. cluck (c), cerebral (,c, cq), palatal (cj), dental (cc), side (ck).

D d. E. *d*o (d); Sc. *d* (,d); Ad. *d* (dd).
dh. E. *th*e.
dzh. E. *judge*.
dy. Hungarian Ma*gy*ar (dj).
E e. F. é (e); E. m*e*n (eə, ea, è).
ee (ē). E. m*a*ne (ee, ē); F. bête (eeə, ēə, eea, ēa, èè).
ea. F. v*in*.
Ə ə. E. n*u*t.
əa. F. *un*.
F f. E. *f*ace (f); Greek φ (ph).
G g. E. *g*o (g); F. *g*ueux (gj).
gh. G. ta*g* (gh), tei*g* (jh); A. *gh*ain (grh).

H ʜ (,h) *he* (ʜ) (*h* must not be used in this sense); A. *hh*a (ʜh).
h. Only used to form digraphs.
ʜ*w*. E. *wh*eel.
ʜ*y*. E. *h*ue (yh).
I i. E. b*ee*n (i), b*i*n (iə, ì); Welsh *u* (ih).
ii (ī). E. b*ea*n.
iu. E. v*iew*.
J j. (See *dy*, *ly*, *ny*, *gh*.)
K k. E. *k*eep (k); F. *qu*eue (kj).
kh. G. da*ch* (kh), di*ch* (ch); Spanish *j* (x), A. *kh*a (krh?).
L l. E. *l*o (l); Polish barred *l* (ll); Sc. *l* (ˌl).
lh. W. *ll*.
ly. I. gi*gl*io (lj); Spanish *ll* (lj).
M m. E. *me*.
N n. E. *n*ay; Sc. *n* (ˌn); Dental *n* (nn).
ng. E. si*ng*.
a. See a*a*, ə*a*, e*a*, o*a*.
ny. F. monta*gne* (nj); Spanish ñ (nj).
O o. E. *o*mit (o); F. homme (oə, oa, ò); I. onde (uə, ù).
oo (ō). E. b*o*ne (oo, ō); I. solo (uuə, ūe, ùù).
oe (ö). G. st*oe*cke (oe, ö); F. j*eu*ne (eo, ë) *e muet* (eo, ë); Gaelic l*ao*gh (oh).
ooe (ōe, öö). G. G*oe*the.
oa. F. n*on*.
P p. E. *p*ea.
Q q. Arabic *q*aaf.
R r. E. *r*ay (r), ai*r* (ɹ), a*re* (ʀ), va*r*y (ˌɹr); Sc. *r* (ˌr); Lip-trill (brh).
rh. W. *rh*ag.
S s. E. *s*ee (s); Ad. *s* (ss).
sh. E. *sh*e (sh); Sc. *sh* (ˌsh).
sy. Polish *s′* (sj).
T t. E. *t*ea (t); Sc. *t* (ˌt); Ad. *t* (tt).
th. E. *th*in.
tsh. E. *ch*eese.
U u. E. p*u*ll.
uu (ū). E. p*oo*l.
ue (ü). G. h*ue*tte (ue, ü); Swedish *u* (uh); Polish *y* (eh).
uue (ūe, üü). Long of *ue*.
V v. E. *v*ie (v); G. *w*ie (bh).
W w. E. *w*eal.
X x. See *kh*.
Y y. E. *y*et.
yh. See ʜ*y*.
Z z. E. *z*eal (z); Ad. *z* (zz).
zh. F. *j* (zh); Polish *rz* (zrh).
zy. Polish *z′* (zj).
(’). Indistinct murmur *bed’*.
(‘). Slight whisper *bet‘*.
(,). Stop, to separate digraphs (,); Arabic *alef* (ˌ), *hamza* (;), *,ain* (ɛ).
(-). Glide to connect letters in different words.
(·) or (′). Place of accent.

Examples in the finer approximation.

English (without any accented letter). Dhi iənveən·shən aov rəit·iəng, dhi greet·əst aend moost iəmpaaoʀt·aent whiətsh dhi yhuum·aen məind ʜaeth eəv·ɹ meed.
Rougher Approximation. Dhi inven·shən aov rait·ing, dhi greet·est and moost impaaor·tant ʜwitsh dhi ʜyuum·an maind ʜath ev·r meed.
Ordinary Spelling. The invention of writing, the greatest and most important which the human mind hath ever made.
German (with the acute accent). Di eərfíndung deər shrift, di gróoeste und bhíchtijhste bhéəlche yee deər méənshliche geist gemákht ʜat.
Rougher Approximation. Di erfind·ung der shrift, di grooest·e und vikht·ighste velkh·e yee der mensh·likhe gaist gemakht· hat.
Ordinary Spelling. Die Erfindung der Schrift, die groesste und wichtigste welche je der menschliche Geist gemacht hat.
Italian (with the long mark). Teəmēr·si dēə·veə sūel di kuēl·leə kōə·zeə
K-an·noə poəteən·tsa di fā·reə-altrū·i mā·leə.

Observe *uē* stands for *u-e*, or the diphthong of *u* and *e* as distinct from *ue* or *ü*, and *ūe* the long of *ue* or *uue*.

Rougher Approximation. Temeer·si dee·ve sool di kuel·le kaaoz·e
K-an·no paoten·tsa di faa·re-altruu i maa·le.
Ordinary Spelling. Temersi deve sol di quelle cose
Ch’ anno potenza di fare altrui male.
French (with accented letters). Kruaarë tu dekuvèr èt-üin-èɪër pròfoᴀd,
S-è- praᴀdrë l-òrizoᴀ pur lè-bòrnë dü-moᴀd.
Rougher Approximation. Kruaaroe tu dekûver et-uen-eroer profoᴀd
S-e praᴀdroe l-orizoᴀ pur le bornoe due-moᴀd.
Ordinary Spelling. Croire tout découvert est une erreur profonde,
C’est prendre l’horizon pour les bornes du monde.

These various styles may be mixed at pleasure, but double consonants *must* always be separated by the stop or accent, thus *an·noə* or *án,noe*, as *ánnoə* would represent a single dental *n*, giving a very different sound.

On a Philosophic Universal Language. By G. Edmonds, *Birmingham.*

On the Deciphering of Inscriptions on Two Seals, found by Mr. Layard *at Koyunjik. By the* Rev. J. Gemmel.

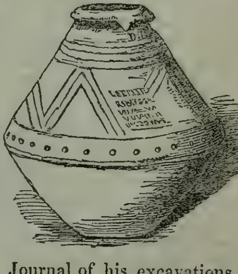
On Celtic, Sclavic, and Aztec Crania. By Prof. Retzius, *of Stockholm.*

The Professor combated the phrenological view that high skulls betokened high intellect. He had gone into schools in this country, and uniformly observed, on looking around, that not more than one in a hundred could be found without the elongated skull and prominent occiput. The same thing was to be said of his native country, Sweden. There were some among the Swedes who had the short, high head, but it was always found that these persons did not resemble the native population, but had black hair, and were allied to the Finlanders or Laplanders. Phrenologists placed the Sclavonian in the Caucasian race; but if this were correct, anatomy was certainly of no use to ethnologists, for it completely contradicted that view. Prof. Retzius then exhibited and described an Aztec skull, which he said was supposed to belong to the ancient Mexicans, who had left the gigantic remains of civilization which had been found in that country, and to be, at any rate, older than the Spanish conquest. These skulls had much the same character as those of the ancient Peruvians, and came under the Mongolian type. These skulls were always small, but the chiefs, who may be regarded as the nobility, had elongated heads. The whole American people belonged either to the short-headed or the long-headed class, the former being found on the west side, and the latter on the east side of the continent.

On a Roman Sepulcral Inscription on an Anglo-Saxon Urn in the Faussett Collection. By C. Roach Smith, *F.S.A.* (*In a Letter addressed to* Thomas Wright, *F.S.A.*)

The author presents, in the first place, a general view of the progress made in separating the Anglo-Saxon remains from the Roman, and adds the following illustration of the care required in this investigation:—

"An urn, which I suspect came from Norfolk, is in the museum of our friend Mr. Joseph Mayer of Liverpool, in the Faussett Department. While last autumn I was looking over the Kentish Saxon antiquities, I was struck with the shape of this vase, and examining closely, I discovered upon it a Roman funereal inscription as follows:—



D. M.
LAELIAE
RVFINAE
VIXIT. A. XIII
M. III. D. VI

scratched with some sharp tool.

"Not finding any mention of it in Mr. Faussett's Journal of his excavations in Kent, I concluded it did not belong to that county, as indeed I doubted from the first. But I find a memorandum of his referring to two Roman urns from Norfolk which belonged to one of his neighbours, and one of these I suspect is the urn now under our consideraton; but, if so, it is remarkable he did not notice the inscription. The antiquity of this inscription I see no reason to doubt; and I can instance names and funereal inscriptions scratched, in like manner, upon sepulcral urns of the Roman period.

"This urn, then, we cannot avoid believing to be Roman. But it is, doubtless, of a very late period, that probably which verged upon the Anglo-Saxon. You will see at once what are now my opinions on the Derby urns, and the fragment of the duck-billed fibula found in one of them. All the Frankish and Saxon ornaments may be traced to Roman archetypes; and though I know of no instance where one of these peculiar

fibulæ has been found in an interment purely Roman, yet intercourse may have induced Romans occasionally to use the ornaments of foreigners, and the intercourse of the Saxons with Britain you know had been pretty considerable before the Romans departed. Other questions which I need not at present go into, suggest themselves.

"I now draw your attention to the discoveries of Mr. Neville at Wilbraham on the borders of Cambridgeshire and Essex.

"Here we find skeletons with weapons, &c., undoubtedly those of Saxons, in juxtaposition with urns containing *burnt bones*; such we never find in Kent, except when a Roman grave has been disturbed by a Saxon interment.

"I think we shall have to refer most of these urns containing burnt bones to a late Roman period just preceding that of the Anglo-Saxon; and the fact of these urns being found placed over the bodies of Saxons, proves, I think, not that the urns were originally so located, but that the Saxons, when interring their dead upon the site of an old burial-ground, found the urns with burnt bones, respected them, and replaced them in the newly-made graves."

On the Ethnology of England at the Extinction of the Roman Government in the Island. By THOMAS WRIGHT, *F.S.A.*

On Inscriptions in Unknown Characters on Roman Pottery discovered in England. By THOMAS WRIGHT, *F.S.A.*

GEOGRAPHY.

On late Explorations in Africa. By C. J. ANDERSON. *Despatch from* George Frere, *Esq., H.M.'s Commissioner at the Cape of Good Hope, relating to* Mr. C. J. Anderson's *Journey to Lake N'gami. Communicated by the* EARL of CLARENDON.

The following summary of the results of Mr. Anderson's explorations is from the despatch:—"The country in the immediate neighbourhood of Lake N'gami is inhabited by tribes under the authority of the chief Letiholetebe, who, I regret to learn from Mr. Anderson, has permitted the sale of slaves to the Boers. Mr. Anderson attempted to proceed from the lake up the Trionghe river to visit Liberbe, the capital town of the Bavicko country, said to be about nineteen days' journey by land from the lake; but his proposal met with so little encouragement from Letiholetebe, that, after ascending the river for several days, he was obliged to return. He, however, learns that it was the centre of a great inland trading place, visited by the Mambari, who purchase slaves, ivory, &c. for the Portuguese residents at the settlements on the west coast, and also by the Ovapangari and Ovapangama, from the country north of the Ovambo, between the 17th and 18th degrees of south latitude, who formed an intercourse with the tribes under Sebitoane, Letiholetebe, and others to the eastward. But perhaps Mr. Anderson's success may be considered of peculiar interest and importance, as showing that this well-watered country,—the inhabitants of which have proved themselves so friendly and well-disposed towards English travellers, or as Messrs. Oswell and Livingstone describe it, "the great highway into a large section of the continent of Africa,"—may now be reached in from forty to sixty days from Walfisch Bay, with which communication by sea from Cape Town is easy; and that the traveller can reach this starting-point unmolested by the interference of the emigrant Boers, or by attacks by the plundering Griguas, and without encountering the perils of Kalahari Desert."

Report of the late Expedition up the Niger and Tchadda Rivers. By Dr. W. BALFOUR BAIKIE, *R.N., F.R.G.S., addressed to the Lords of the Admiralty.*

After detailing the preparations he had made for his expedition, Dr. Baikie, dating on board the African mail-steamer Bacchante, Sierra Leone, January 3, 1855, reports as follows:—"We have explored about 250 miles of the river Tchadda beyond the

furthest point attained by Allen and Oakfield in 1833, and reaching to about fifty miles of the meeting of the Faroe and Binue, have established the identity of the Tchadda with the Binue. We have established the navigable nature of the river during the rainy season up to our furthest point; and seemingly, as well as from the information of the natives, considerably beyond. We have encountered several new tribes; have inquired into the resources, &c. of the various countries; and have ascertained the friendly disposition of the natives. From numerous careful observations, we can almost demonstrate the incorrectness of Dr. Barth's astronomical positions; our furthest point east being 11° 30′, at which time we were considerably beyond Hamaruva, and almost certainly, at the furthest, within fifty miles of the junction of the Faro, which was placed by that gentleman in longitude 14° east." Dr. Baikie states, as the result of his expedition, that he will be able to lay before the Admiralty a tolerably accurate chart of the entire rivers, and materials for a much improved map of the surrounding countries. He proceeds:—"With the assistance of Mr. Crowther, we have satisfied ourselves of the general desire of the natives to receive instruction and to admit teachers, and also of their wishes to carry on trade with us. We are enabled to report favourably on the climate, having encountered but little sickness, and, providentially, not lost a single life. .....Inability to cut fuel was the principal cause of our final stop;—the Krooboys, also, were nearly exhausted by the immense labour consequent on the employment of miserably insufficient tools. Scurvy likewise made its appearance among the crew, apparently from an improper amount of nourishment. The actual turning back of the vessel took place while Mr. May and I were absent in the gig, endeavouring to make a higher ascent. The furthest point eastward reached by the party was about latitude 9° 30′ north, and in longitude 11° 30′ east. They believed, from information received, that they were at that place not more than fifty miles from the Faro. The different native tribes, for the most part, gave them the most friendly reception." Dr. Baikie and his party reached the mouth of the river, on their return, on the 4th of November 1854. "During the voyage the amount of sickness was very little, and every case of fever yielded to the careful, but free administration of quinine, which was also employed largely as a prophylactic, and, as it seemed, with great benefit. The trading part of the voyage was a great failure." In conclusion, Dr. Baikie remarks that, "from all appearances, there is less war and turmoil, and a greater feeling of security along the river than formerly; as detached huts and patches of cultivated ground are now to be seen along the banks, none of which, I am assured by Mr. Crowther, existed during his visit in 1841."

Remarks on the late Arctic Expedition, and on the several Completions of the North-west Passage. By Capt. Sir E. BELCHER, *R.N., F.R.A.S.*

On the Importance of Periodical Engineering Surveys of Tidal Harbours, illustrated by a comparison of the Surveys of the River Mersey, by the late F. GILES, *C.E.*; *and the Marine Surveys of the Port. By* J. BOULT.

Mr. Boult pointed out the extent to which the sea had encroached upon the land at the mouth of the Mersey, the average yearly encroachment being about six yards; and showed the consequent necessity of repeated and minute surveys, for the purpose of discovering where the sea encroached, and where deposits were laid down, with the view of preserving the harbours undeteriorated.

Notes on the Portuguese Possessions of South-west Africa. By Mr. Consul BRAND.

An Account of a Visit to Medina from Suez, by way of Jambo. By Lieut.-Col. BURTON.

Journey across the Rivers of British Kaffraria. By the Rev. F. FLEMING.

This paper described a journey from the Great Kei to the Q'Nabaga Rivers, including a description of some fossil remains which Mr. Fleming discovered near Q'Nabaga.

On Improved Monographic Projections of the World. By James Gall, *Jun., Edinburgh.*

Cylindrical maps alone can represent the whole world in one diagram. There are only three features in which a cylindrical map can be accurate:—1. in Orientation; 2. Polar distance; and 3. Proportion of area; but if one of these be obtained, the others must be sacrificed. The best projection is that which will divide the errors, and combine the advantages of each. Mercator's projection sacrifices Form, Polar distance, and Proportionate area, to obtain accurate orientation for the navigator; whereas, to the geographer, Form, Polar distance, and Proportion of area are more important than Orientation.

Polar distance is obtained by making the degrees of latitude equal.

Proportion of area is obtained by projecting the degrees of latitude orthographically.

In these two projections orientation can be correct at only one line of latitude; but if we select the 45th degree of latitude, and make the orientation correct at that line, the error is halved on each side and the distortion less offensive.

The projection which unites all the advantages of the three, in the best proportion, is obtained by projecting the degrees of latitude stereographically, and selecting the 45th degree of latitude as the line of correct orientation. It will possess the following advantages:—

1. It gives a more accurate representation of geographical forms.
2. It gives a representation of the *whole* world, including the poles.
3. It represents polar distance and proportionate area better; and
4. It saves 25 per cent. of the space occupied by Mercator's.

Note.—There is no formula by which Mercator's chart may be projected accurately, the orientation of each degree being obtained by calculation; but an approximation may be obtained (up to the 85th degree) by projecting the latitudes from a point behind the quadrant, nine degrees higher than the base, and one-third of the radius distant from the centre. This approximation is so close, that it cannot be distinguished except by careful measurement, and is of use for particular purposes.

An Account of the Exploration of the Isthmus of Darien, under Capt. Prevost, *R.N. By* J. M. Inskip.

The greater part of the country was extremely wooded, so much so that the party had to cut their way through it, sometimes only being able to advance at a rate of about two miles to two miles and a half a day; and other parts were extremely swampy, presenting almost equal difficulties to the explorers. He gives an opinion, that, before any complete survey can be made, it will be necessary either to conciliate or subdue the Indians, and that the construction of a canal across the isthmus will be a work alike of great difficulty and expense. A railway, however, may be constructed without probably any greater difficulties than exist in many parts of England.

Extracts from Letters dated Pungo, Andongo, and St. Paul de Loanda, describing his Journey across Tropical Africa. By Dr. Livingston.

These papers speak of the great value of Angola and other Portuguese possessions in Africa, commercially, more especially to the British, by whom they have been long neglected, principally, it would appear, from the slave trade having interfered with legitimate commerce, which, however, is now being rapidly developed; the export slave trade having been altogether abolished, and the condition of the domestic slaves very much ameliorated.

On the Preadamitic Condition of the Globe. By Prof. MacDonald.

The Geographical and Historical Results of the French Scientific Expedition to Babylon. By Dr. Julius Oppert.

Dr. Oppert stated that he had spent two years on the site of Babylon, examining the cuneiform inscriptions on the bricks and stone slabs. Babylon covered rather more than an area of 200 square miles, being about two and a half times as great as

the site of London. But all this space was not inhabited, there being immense fields to supply the city with corn and pasture in case of siege. Dr. Oppert gave a brief description of the cuneiform inscriptions, and the principle on which particular characters were chosen to represent particular objects and ideas.

Notes on the late Arctic Expeditions. By Capt. SHERARD OSBORN, *R.N.*

On Hartlepool Pier and Port as a Harbour of Refuge. By Sir B. F. OUTRAM, *M.D., C.B., F.R.S.*

Notes on the Hindú-Chinese Nations and Siamese Rivers, with an Account of Sir John Bowring's *Mission to Siam. By* HARRY PARKES, *H.M. Consul, Amoy, China.*

The author states that the population of Birma, Siam, and Cochin-China, had formerly been considerably over-estimated. The population of Birma was about five millions, that of Siam six millions, and that of Cochin-China thirteen millions. This would give to Birma and Siam a population of twenty-three to the square mile; but when due allowance was made for the extent of the jungles, and other land incapable of habitation, this scale would not appear low. Cochin-China has a greater population on account of its greater fertility, industry, and enterprise. The products of these countries were generally the same,—rice, cotton, bees'-wax, and various metals. Siam had the greatest resources, and must receive the preference as a commercial nation; for though Cochin-China had gold and other precious metals, it was deficient in staple commodities. The Malayese were subjected to Siam, but only gave tribute when Siam was in a condition to enforce it. As a distinct language, it was considered by the best scholars that Siamese could not have existed for more than four centuries at the most; their sacred writings were still in the Camboja character, and the language of the chiefs had many Camboja words, they being descended from that people, who appeared to have subjected the Siamese. The dress of the Siamese was very picturesque, and the mountaineers, like the mountaineers of Scotland and other countries, wore dresses of a plaid pattern. With reference to Sir John Bowring's mission, Mr. Parkes stated that it was rendered necessary in consequence of the monopolies, restrictions, and impediments placed on our trade by the last king of Siam. In 1826 the British obtained permission to trade in Siam, but the treaty was not observed during the last reign. The present king came to the throne in 1851, and Sir John Bowring visited him in April of this year, and met with a very friendly reception. Mr. Parkes then described the advantages of the treaty concluded. Instead of the very restrictive duties formerly imposed, there was now to be an import duty of three per cent., payable either in money or in kind, and permission was given to the British to purchase houses and lands, and even build ships in their rivers. And in accordance with the memorial sent to the British Government from Glasgow and other places, Sir John Bowring arranged that a consul be appointed to take British interests under his charge, on the same principle which obtains in the Levant and China. The prospects of commerce with Siam were very hopeful. The Siamese were not a manufacturing people, and would be ready to take manufactures in return for their produce. In 1840, the value of our trade with Siam was about half a million, and there was reason to hope that in ten years hence it might amount to £4,000,000 or £5,000,000. Their rice was perhaps the best in the world, and the cultivation of this crop might be extended to almost any amount. Mr. Parkes exhibited several of their books, which consisted of prepared leaves tied together, and specimens of native hemp, the wood of the gamboge tree, gamboge in its rough manufactured state, and specimens of their hardware, cutlery, and domestic utensils. With regard to their physiological characteristics, they were described to be 5 ft. 2 in. in height, being shorter than the Chinese and taller than the Malays. Their beards were plucked out by the roots, the hair was shaved from the back of their heads, leaving a tuft on the front of the head, which being with both sexes kept cut to the length of an inch, presented very much the appearance of a blacking-brush. The teeth of both sexes were dyed of a deep black colour, and their mouths were conti-

nually filled with a quid of tobacco, betel, and other condiments. There were many free schools in Siam; education was conducted by the priests, and four-fifths of the people could read. Their principal town, Bankok, had a population exceeding that of Glasgow.

Hurricanes in the West Indies and the North Atlantic from 1493 *to* 1855. *By* Señor Andres Poey, *of Havana.*

A chronological table, comprising 364 cyclone hurricanes, which have occurred in the West Indies and in the North Atlantic within 362 years, from 1493 to 1855, with a bibliographical list of 300 authors, books and periodicals.

Account of the Ascent of Mont Blanc by a new Route from the Side of Italy. *By* J. N. Ramsay.

Ascent of the Mountain Sumeru Parbut. *By* Capt. Robertson.

In October 1851, Lieut. Sandilands, of the 8th (the King's regiment), and myself visited the hot springs of Jumnotsi. One of the Brahmins of Kursallee, who acted as our guide, showed us a memorandum of Lieut. Yule, of the Bengal Engineers, recording an attempt to reach the summit of the ridge which separates the waters of the Jumna from those of the Touse. At the season when Lieut. Yule made this attempt there was a great deal of snow on the mountain, and he was unable to reach the summit of the ridge; but it appeared to him that at a later season of the year the point might have been reached without difficulty; even the snowy peaks above, it seemed to him, might not have proved inaccessible. Confiding in Lieut Yule's opinion, and there being very little snow on the mountain, Lieut. Sandilands and myself resolved to make an effort to reach the summit of one of these peaks called Sumeru Parbut. We promised the Brahmin 50 rupees if he would accompany us and act as our guide. He agreed to do so, and engaged five rajpoots to join the party.

On the 28th we slept at Reshi Wodar, a spot near the hot springs, two hours and twenty minutes from Kursallee, the last village on the Jumna. On the 29th we removed our tent from Reshi Wodar to a small plateau under a peak called Dhotee Tiba. This plateau is situated in the region between the upper limit of the growth of shrubs and the snow, at about one-half of its height. The elevation above the sea was probably between 13,000 and 14,000 feet. After the sun set the air became intensely cold. A soda-water bottle, filled with water, we found next morning burst. We had employed a gang of people to carry up wood to our bivouac, and kept a fire burning all night in front of our tent.

Mr. D'Aguilar, the chaplain of Meerut, who had arrived at Kursallee in the morning, hearing of our projected attempt, resolved to join our party, and came up to the bivouac in the evening. Mr. D'Aguilar was badly provided with blankets and clothing, and he suffered so much from the cold that he was unable to sleep. He spent the night miserably, cowering over the fire, with his blankets huddled round him. Sandilands and I lay down on our cots without undressing, and covering ourselves with a pile of blankets, slept soundly, and did not feel the cold. The Brahmin, the five rajpoots, and the two guides of Mr. D'Aguilar, slept in Mr. D'Aguilar's tent. The whole party stript to the skin; they lay down close together, and covered themselves with their clothes and blankets. This is the way that the mountaineers always bivouac. The ascent from Reshi Wodar to our tent occupied two hours and nine minutes.

At ten minutes past eight on the following morning we left our tent. In one hour and thirty-five minutes we reached a flat-topped glacier. Here the breathing and vision of Sandilands and several of the guides were a good deal affected. From this point to the summit of the ridge, which separates the feeders of the Jumna from those of the Touse, called by the natives Banderpouch ke Ghattee, we were an hour and twenty-one minutes. From the top of this ridge—which, I believe, was never before reached by any travellers, and which the natives affirmed had never been reached either by them or by any inhabitants of their valley—the view was magnificent. Below us was a great valley of ice, the glacier from which the Touse issues.

On the right of the glacier rose the three great Jumnotsi peaks, designated in Sheet 65 of the Trigonometrical Survey of India Black E, Great E. and Little E, the altitudes of which, as given in map, are 21,155, 20,916 and 20,122 feet. The peaks designated in the Trigonometrical Survey Great E. and Little E. are the two summits of a mountain which the natives call Banderpouch. On the left the glacier was bounded by a wall of precipices, terminating in the lofty snow-covered peak of Sumeru Parbut. The height of this peak is not given in the Survey Map; but, from its appearance, as compared with that of the measured peaks, and also from the height it rises above the limit of perpetual snow, I should estimate its altitude at about 18,000 feet. The altitude of Banderpouch ke Ghattee I estimate at about 16,000 feet.

In making my agreement with the Brahmin, I was under the impression that Sumeru Parbut was one of the measured peaks, and it was not until I reached Banderpouch ke Ghattee that I discovered my mistake. As soon as I did so, I wished to alter our route, and to attempt the ascent of Banderpouch. But the Brahmin would not agree to this: he affirmed that Banderpouch was inaccessible. We therefore turned to our left, and scaling the precipice, and creeping along its narrow serrated ridge, in two hours and thirty minutes the Brahmin and myself reached the summit of Sumeru Parbut. Mr. D'Aguilar, finding that he could not proceed further without being obliged to bivouac for another night in the cold, had left us at the foot of the ascent leading to Banderpouch ke Ghattee. Lieut. Sandilands reached a point within about half an hour of the summit, when he found himself so severely affected by the rarefied atmosphere that it was physically impossible for him to proceed. When he turned he was attended by only one of the rajpoots, all the others having deserted him before.

My Brahmin guide, a very fine athletic young man of 25, did not seem to suffer in the least, but on our return to our tent he was unable to eat his bread. My eyes ached a little, my breathing was a good deal affected, and my spirits very much depressed; but I retained sufficient energy and physical power to persevere almost continuously in the exertion of climbing, and on my return to our tent, my appetite was not at all affected, and I ate a hearty supper. It was a quarter to two when we reached the summit. When I commenced my journey to Jumnotsi I had no intention of attempting the ascent of any culminating point, and did not, therefore, provide myself with any instrument, excepting a thermometer and a surveying compass. Several weeks before I had broken my thermometer, and was therefore unfortunately totally destitute of the means of making observations. I, however, observed that the surface of the snow was melting,—a little rill of water trickled down on the face of a fragment of rock which projected through the snow. This proves that at two o'clock in the afternoon on the 30th of October, at an altitude of 18,000 feet, the sun has sufficient power to raise the temperature above the freezing-point.

At ten minutes after two we commenced our descent. In 1 hour and 27 minutes we reached the bed of the glaciers; in 53 minutes Banderpouch ke Ghattee, where we rejoined Sandilands and one of the rajpoots; in 57 minutes the lower edge of the Dhotee Tiba glaciers; and in 1 hour and 17 minutes, at 38 minutes after six, we rejoined our tent. The total time occupied in the descent, from the time we left the summit until we reached the tent, was 4 hours and 28 minutes. On the following day we continued our descent to Kursallee, which we reached in 4 hours and 11 minutes. Before reaching the edge of the Dhotee Tiba glacier we had been enveloped in a dense mass of cloud which entirely concealed every landmark. We were very apprehensive that we should have missed our tent. Had we done so, we should probably have perished before morning. Next day, before we reached Kursallee, the first snow of the season began to fall, so that the opportunity of further exploring the icy regions of the mountains was gone.

I am now about to rejoin my regiment in India, and am likely to be stationed within reach of the Himalayas, so that I hope, in the autumn of 1854 or 1855, to pay another visit to Jumnotsi. Should I do so, I purpose to encamp in the plateau between Dhotee Tiba and to devote three or four days to an attempt to ascend one of the great Jumnotsi peaks, having found by experience that I suffer comparatively little from the rarefaction of the atmosphere; and having tested the intrepidity and energy of the Brahmin guide, I am in hopes, if I can discover an accessible path,

that I shall be able to reach the summit of one of the Jumnotsi peaks. I conceive that the successful ascent of so lofty a mountain, and the demonstration which would be thereby afforded of the capacity of the human frame for physical exertion, at an elevation of upwards of 20,000 feet, would in itself be an interesting fact. I should also endeavour to carry up with me a thermometer and barometer; and if able to register observations made with these instruments on the summit of the mountain, such observations would doubtless be esteemed both valuable and interesting.

Notices of Journeys in the Himalayas of Kemaon. By ADOLPHE SCHLAGINTWEIT *and* ROBERT SCHLAGINTWEIT. (*Communicated by* Col. SYKES, *F.R.S.*)

We left Nainee Tal, where we had made several geological excursions in the outer ranges of the Himalayas, on the 16th and 20th of May, taking two different routes to Milum in Johar. My brother Robert went by Almorah Bageom and Gheigaon to Munshari, and from thence to Milum; I myself went up the Surjoo valley to Kathi, the last village in the Pindaree valley, for the purpose of examining the Pindaree glaciers. When I was on the spot I had some conversation with the natives about a pass across the high chain of Nanda Kot and Nanda Devi from Pindaree directly to Milum, which I had been informed in Nainee Tal had some twenty-five years ago been made by Mr. Traill, Commissioner of Kemaon. I soon found that the brave Danpoor people would be more willing to go than I had at first expected; I promised them a good remuneration, gave them each a piece of green gauze for protecting their eyes against the snow glare, of which they were exceedingly afraid, and allowed them to offer to the Nanda Devi on the top of the pass some goats and other things, which, being very superstitious, they considered of the utmost importance. Only one man out of the one hundred who had accompanied Mr. Traill twenty-five years ago could be found, being the only one who knew anything about the route; he was a valuable guide. Two strong Danpoor men accompanied me with thirty people.

I left Kathi on the 28th of May, arrived at Pindaree on the 29th, slept on the 30th on some rocks free of snow above the Pindaree glacier, and on the evening of the 31st we encamped on the other side of the Nanda Kot range in the highest Koeriko on the foot of the Soan glaciers. We had a rather uncomfortable night on the 30th, where we slept without any tent or other protection in the open air, in a place called Shoeraji Koerik, on the right side of the Pindaree glacier above the limits of all shrub vegetation; on account of the very steep ascent over rocks, it would have been indeed impossible for the people without great risk of life to have carried up great heavy loads like tents, &c., all which I had therefore sent round by Namik. We started on the 31st at half-past 2 A.M. I was obliged to leave behind four persons who had got very unwell in the night. The snow was hard and easy to walk on, on account of the cold night, and we steadily rose higher and reached the summit of the pass at 8 o'clock:—only the last ascent to the pass over very steep icy snow, when we were obliged to cut hundreds of steps, was rather tiring for men already fatigued by a bad night and a long march. I halted one hour on the pass for making my observations, and then we went on. The pass does not lead over the main ridge of the snowy range; it only leads to the extensive snow-fields which feed the Pindaree glacier, since the glacier coming down a very steep valley is broken up in icy cliffs and needles. We had to walk for nearly two hours over the snow fields of the upper Pindaree glacier before we reached the second pass which leads down to the Soan valley. Here we began to feel the effect of the sun and the snow-glare. My people lay down constantly on the ice, and I had much difficulty in pushing them on. The thermometer, which had been with us on the pass 32° Fahr., rose between 10° and 11° when we were walking nearly on the same level, but sheltered from the cold wind, to 55° in the sun, which we all found an oppressive heat up here. At eleven we reached the second pass, from whence we discovered Nanda Devi and the Milum mountains.

All the time we had been in sight of the high snowy peaks which surround the Pindaree glacier I had been able from several places to take angles to the principal points, and I hope my observations may not be without some result for the orography and geology of this part of the snowy range. I halted one hour and a half again on

the second pass, which is only very little lower than the first, and then we descended over steep snowy declivities to the Soan glacier. After halting several times for making my observations, we arrived at 5 o'clock at the Nassapanpatti Koerick in the upper Soan valley, where we slept very well under the shelter of some rocks. The next day we went down to Martoli, and on the 2nd of June I had the pleasure of meeting my brother Robert at Milum, who had been going from Almora by Munshari to Milum with the greater part of our instruments.

I am not able to give absolute heights for the passes, on account of not having received the corresponding observations from the plains; but calculating my observations by those made by my brother Robert, and assuming the height of these places as given in the maps (though I cannot be responsible for them in any way), I find that the height of the pass will be about 17,950 English feet. I had not the least suffered in the eyes from the snow glare, and some of my people who had got inflamed eyes were soon all well again. I had still with me my draftsman Eleazar and one Kidmutgar, who both wanted to accompany me, but the poor people got fearfully exhausted up there, and I was very glad to see them safely brought down to the foot of the Soan glacier.

At Milum we found that Manee, the clever Putwaree of the Johar district, had made the best arrangements he could in this place, and we made ourselves quite comfortable in a little native house cleaned out for us. We stopped some days at Milum for putting up our instruments, and setting regularly to work our assistants, plant collectors, &c. Then my brother Robert and myself went up to the foot of a glacier just above the Pachu village, in order to take a closer view of the Nanda Devi group which rises just behind the glacier. We sent two days before seven people to examine the different sides of the little glacier valley, and on the 10th of June we succeeded in reaching the summit of a rocky crest just stretching out eastward from Nanda Devi, from whence we had a very extensive view of all the Himalaya range, from Dharma over Oota Dhorra to Nanda Devi and the Nanda Kot group. The height of the peak is as nearly the same as possible as that of Traill's pass, about 17,900 English feet; but being no pass, but an isolated peak surrounded by deep precipitous valleys, it was a much better place for studying the structure of this part of the Himalayas, and for taking angles with our theodolite, than the pass had been.

We left our camp at four o'clock in the morning, and after a continual ascent over rocks and snow masses on the right side of the Pachoo glaciers, we reached the summit at half-past 10 A.M. We found no particular difficulties; for it would be scarcely worth mentioning those which are always to be met with in going up to such a place. We were accompanied by thirteen strong Bhotias for carrying our instruments, some ropes and some provisions. The top was rather confined, and we managed to find a little lower a sheltered place where we got up a little fire with some bits of wood brought up from the valley, and there we placed our Bhotias to warm themselves until we had completed our observations on the top. We were able to remain from $10^h\ 30^m$ A.M. until 3 in the afternoon; the temperature was from 35° to 38° Fahr. Some of our people complained of severe headache; we ourselves experienced only once a little feeling of headache, which soon went off again. The ascent was rapid and agreeable after having passed the dangerous and much-creviced places of the snow. On our return we went on sliding down the pretty hard snow-fields with great velocity, and we arrived at half-past five at the foot of the mountain glacier, whence we walked down leisurely to our camp, where Manee and our people awaited our arrival.

After staying two days more for completing our observations, we returned to Milum, where our young assistant Daniel, a young East Indian of good education, had made very good barometrical observations, &c. during all the time. We remained in Milum till the 16th, occupied with magnetic observations and photographic experiments. Our photographic apparatus, which acted very well, produced a marvellous effect among the Bhotias. We shall have the honour of sending you some of our photographs from Simla or Agra, where only we shall find time to take positive copies from our negatives.

On the 16th we again left Milum to examine the great Milum glacier. It is the largest we have seen, eight or ten English miles long and 3000 feet broad; no glacier in the Alps is equal to it in size.

On the 18th we pushed on our camp to a small rocky crest, which rises in the midst of snow and ice masses of the glacier; it is called Rata Dak or Red Mountain. It offered us an excellent view of the mountains surrounding the upper part of the Milum glacier. The height of the mountain is about 16,500 English feet; we were much above the limit of all shrub vegetation, and only light loads could be carried up through the narrow and steep rocky ascent, over which passed the only possible way. We had the first day a want of fuel. Our sixteen Bhotias declared it was impossible to go on any further. They walk well on rocks, but they are much afraid of snow and ice, and especially of the glacier crevices. Nevertheless, we left our camp early in the morning on the 19th, fastened to each other by strong ropes, which materially increased the courage of the Bhotias. We went on over the glacier. After some hours we reached the most difficult place, a very steep descent of the glacier, about 1000 feet high. One of us went on before fastened to the rope for examining the road, and for ascertaining whether the fresh snow on the sides of the crevices was solid enough for supporting us. Our people followed with quiet resignation; they had a long time before given up every pretension to a judgment of their own of the way we had to take.

After several attempts we succeeded in reaching the upper part of the descent, and we found ourselves on comparatively level snow fields. We thought ourselves to be pretty near to the end of our wandering,—a black rocky crest on the termination of the Milum névé; but as is often the case, the snow masses seemed to become larger and longer the more we ascended. The influence of the height made itself now remarkable in a very different way with the different people. We ourselves felt not the least headache, we had been acclimatized by degrees, and we found our thick Indian pith hats an excellent protection against the sun, which is felt in India much more than in the Alps; some of our people who tried to stimulate themselves by brandy complained of severe headache, but we all were tired and exhausted in a remarkable way, which may have been owing partly to the fatigues of the ascent, and partly to the rarefied air. At last, at 1 o'clock, we reached the highest part of the snow on the foot of the little rocky crest; the barometer indicated just half the pressure of the atmosphere; it stood at 380 millimetres; compared with Milum, the height must be about 19,100 English feet, or a little more*. We went up to the rocks behind, from whence we had a fine view over a part of Tibetan mountain ranges which lay just below us. We were separated from it by very steep impassable rocky precipices from the south; as is generally the case here in the afternoon, heavy clouds came up, but over Tibet was a clear dark blue sky. Our people urged us to return; at half-past four we started, and went on as quick as we could over the places where we had to fear avalanches, the snow being much softened by the sun; and at half-past five we reached the foot of the difficult steep ascent of the glacier, where we were quite out of danger.

The mountains in the neighbourhood of the Milum glacier offer a great interest for geological researches. The crystalline schists of the central parts of the Himalayas are here overlaid by fossiliferous sedimentary strata of the Silurian formation. We were fortunate enough to gather a pretty large collection of well-preserved Silurian fossils, both near our camp on Rata Dak and on the highest points above 19,000 feet, which we reached, since the mountains are quite void of vegetation. We had a very good occasion for examining the transition from the crystalline schists into the sedimentary strata. We convinced ourselves, that what appears stratification in the crystalline schists is here at least no stratification, but merely foliation or cleavage. The cleavage is easily traceable into the sedimentary strata, where we see therefore (1) cleavage, (2) the true stratification, both often very confused, and difficult in the beginning to be distinguished from each other. We are much pleased with the beauty of the Himalayas in the central parts, and with the glaciers; the forms of the mountains are exactly like the Alps, but the dimensions are much grander. The upper Pindaree valley, the beautiful gorge above Munshari, and the mountains between Pindaree and Milum can only be compared for beauty and grandeur with the finest parts of the Bernese and Savoy Alps. The large Milum valley is like all high similar valleys, rather a little more monotonous; it lies above the limits of all

* 4600 feet higher (the exact elevation above the barometer has been determined trigonometrically).

trees; it can be compared with the elevated valley of the Eugadin in the Grisons, but the valley and the mountains on both sides are about twice as high. In a few days we shall go out to Tibet by Oota Dhoora and Laptel. We go both alone, sending all our followers to Badrinath. We shall be of course disguised as Bhotias. Manee, the Putwaree of Johar, and ten Bhotias with fifteen Joopoos, will accompany us. We take with us a selection of the best and most portable instruments, and if it is in any way possible we hope to go to Mansarower, the holy lakes of Tibet. The only thing we have really to fear, is that the present war between the Tibetans and Nepalese may interfere with our route.

On the Amazon and Atlantic Water-courses of South America. By Señor Susini.

Señor Susini, in his introductory observations, states, that of all the diplomatic questions of the present period, the most important and the most valuable as regards Spain is that of the free navigation of the above-mentioned majestic rivers and their tributaries. The regions watered by the Amazonas, reclaimed from the savage tribes, ferocious animals, and noxious reptiles which now infest them, and traversed by the ploughshare, might be capable of sustaining the population of the entire globe. The district in question is pre-eminently adapted for the growth of rice, which commonly yields there fortyfold, and which is reaped five months after being planted in the ground, irrespective of season. Señor Susini describes generally the characteristics of the South American climate and soil.

STATISTICS.

Notes on the Application of Statistics to questions in Medical Science, particularly as to the External Causes of Diseases. By W. P. Alison, *M.D. Edinburgh, D.C.L. Oxon. Emeritus Professor of Practice of Medicine, Edinburgh, &c. &c.*

The object of this paper was to show that, notwithstanding the plausible objections often made to statistical inquiries, as being applicable to the support of so many principles, as to give little real support to any, there are various questions in medical science, of the utmost practical importance, which admit of a perfectly satisfactory solution in this way, and *in no other*; because the present state of science does not enable us, nor afford any prospect of our being soon enabled to understand the intimate nature either of diseased actions, or of the powers by which they may be excited or counteracted; in many instances, when, by simply empirical observation, and comparison of numbers, *i. e.* by evidence truly statistical, although often not formally expressed as such, principles may be established which are already amply sufficient for practical application of the highest importance.

The author referred to some observations of his own (in the 'British and Foreign Medical Review,' for 1851), as explaining why these useful applications of statistics should more frequently be made to inquiries in Etiology, *i. e.* regarding the external causes of diseases, than in any other department of medical science; the objects of these inquiries being usually simpler, involving fewer sources of fallacy, and requiring less exercise of judgment, in order that they may be prepared for decision in this way, especially when the observations may be made on organized bodies of men, as on military and naval service, where all the conditions capable of affecting the result are known to, and may often be varied by, the observers; and further, he directed attention particularly to the fact, that the *positive* observation as to an alleged effect following the application of the alleged external cause of disease, is very often supported by a large body of *negative* observations, hardly appearing to require expression in words, and therefore often overlooked, but truly essential to the validity of the inference, and giving it a degree of authority resembling that of

calculations of chances, very often amounting to that of the *instantia crucis*, but which is frequently misunderstood.

The principles thus acquired, by the mere force of numbers, as to the external causes of diseases, involving the knowledge of the means of preventing them, in the last half-century, he considers to be of such practical importance as to bear a comparison with the knowledge acquired during that time in any other department of science; but unless this last peculiarity, of the amount of negative observation which supports the positive observation, is duly considered, the strength of the evidence is often most unfortunately underrated.

The most extraordinary example of such observations, strictly empirical, establishing a principle as to the external cause of a disease of extreme malignity, which is adequate to its extirpation from the face of the earth, is in the case of Vaccination. No information that we possess of the nature or mode of action of the *virus* of small-pox, could have led us even to conjecture that it would undergo the change that is now ascertained, simply by observations statistically arranged, result from its passage through the body of the cow, *i. e.* that, if subsequently applied, in a quantity almost infinitesimally small, to the human body, it would excite a local specific inflammatory process, devoid of danger, and incapable of communication through the medium of the air; and that this process once undergone should not only protect the living animal matter in which it is excited against any action of the virus in future, but should act *prospectively* on the matter, which may constitute the body of the same person after 60, 70, or 80 years,—either totally preventing all effect of the virus, or, if an effect is produced even at that distant period, so far *modifying* it as to render it almost absolutely innocuous at a period when we know that the living structure has been repeatedly worn down and built up again, and can no more be said to be *the same* as went through the process of vaccination in infancy, than, according to the ancient paradox, a man can be said to have used the same *water* twice who has bathed twice at the same spot and in the same *river*.

It is, in like manner, by simply empirical observation, *i. e.* by Statistics, that we have acquired within these few years information touching the extension of another epidemic, sometimes attended with peculiar interest and fatality, the puerperal fever, which enables us almost with absolute certainty to predict that its propagation after the manner of an epidemic may hereafter always be prevented; the observations of Dr. Semmelweiss, at the great Lying-in Hospital at Vienna, where 6000 births take place in a year, and where the deaths in child-bed were reduced to the extent of 400 in the first year, that the precautions founded on these observations were enforced (coinciding in their import with many others, both on a large and small scale, made in this country), having been, as the author maintains, sufficient to prove,—1. That this disease is essentially a case of the diffuse or erythematic inflammation, originating in the uterus, and probably passing through the Fallopian tubes, to affect the peritoneal surfaces, and, like other cases of diffuse inflammation (when prevailing epidemically), varying remarkably in the nature of the accompanying fever, and the practice most effectual in different epidemics. 2. That the immediate exciting cause of this epidemic inflammation in puerperal cases, is a virus identical with that which has been termed the *Cadaveric poison*, often evolved during the decomposition of the human body, but chiefly in the early stage of that process; and that it is transmitted from one patient to another by accoucheurs or nurses, themselves in good health, but to whose persons or clothes it has become attached; and may be prevented from extending in this way simply by preventing all persons who may have been thus brought in contact with it, from having any intercourse with patients in child-bed until effectually purified.

The facts ascertained as to epidemic yellow fever, and its origin in malaria in hot climates, and limitation to districts nearly on the level of the sea—particularly by Reports to the Governments in Germany and France, bearing the names of Humboldt and Dupuytren—and those ascertained as to the different kinds of diet which can produce scurvy, and as to the efficacy of acid fruits in preventing it; and likewise as to the power of cod-liver oil, if not of other animal oils, over the tendency to scrofula, he stated also as principles in Etiology of extreme importance, founded simply on Statistics.

On the subject of the propagation of Cholera, the author coincided with the

opinion stated by the Editor of the 'British and Foreign Medical Review,' that "at the present day, the question is not whether Cholera is contagious or not, but *how often* it spreads by the *agency of human bodies*, and *how often without that agency**."

This he considers to be precisely the same doctrine as he has always held on this subject, because, while contending that the disease "has a contagious property," at least in this climate, he has always explained that he meant that it *could* be propagated by *intercourse of the sick with the healthy*, without pledging himself to any opinion as to the *mode* of communication; and not only without denying the possibility, but at the same time urging the evidence, of its having another mode of diffusing itself at certain times and places, chiefly in the hot climates, so as to form *tainted districts*, of very various dimensions; within which the immediate proximity of the sick seems to have little or no effect either of one kind or another on its propagation.

He alluded to the now generally admitted contagious property of the disease, chiefly as affording a good illustration of the truth and importance of the statistical principle above stated, that a single positive fact may afford conclusive evidence on such a question, if supported, as it often may be when the first invasion of a community by an epidemic is observed, by a large body of negative evidence. As far back as 1832, when the first cases of the true malignant cholera were seen in Edinburgh, it was asserted by him and by others of the Medical Board, then regulating the means of prevention which were adopted, that the very first fatal case which originated in Edinburgh in a person *who had not quitted the city*, was sufficient to establish this point, because it was fully ascertained,—that when the inspection of the whole of Edinburgh and Leith, *i.e.* of not less than 140,000 persons, was complete and minute, this first case occurred in an old woman whose son had had full intercourse with persons sick of the disease at Musselburgh, had been seized with the symptoms in rather a mild form on his return to Edinburgh, and had been nursed by her in a small ill-aired closet, during the whole day next but one preceding that on which she was herself seized. No other case existed in Edinburgh at the time, and no other originated in the town for at least ten days after. If the disease was capable of propagation in this way, she was thus peculiarly and undeniably exposed to the contagion; but if it had not this property, no reason existed why she should be the first affected rather than any other of the 140,000 inhabitants of Edinburgh and Leith, many of whom in all parts of the town and suburbs showed their liability to the disease by becoming affected during ten months following that introduction.

A considerable number of cases have been put on record since that time, where similar facts have been ascertained in regard to the *first introduction* of Cholera into a large community†; and the author is anxious that it should be remarked, that in all such cases it is not the mere fact of a succession of cases having *occurred* in persons having intercourse with patients already affected, but it is the fact of that succession of cases having occurred *among such persons only*, out of a large community in other respects equally liable to the disease,—and for some length of time,—that is relied on as decisive evidence of the efficacy of intercourse with the sick in exciting the disease. If this principle had been admitted as established, when the evidence was complete in 1832, it seems impossible to doubt that it must have so far guided the legal regulations for the prevention of the disease, and that it would have been effectual in saving many lives, especially if combined with the practice, also adopted in Edinburgh in 1832, and since recommended by the Board of Health in London, and adopted in different parts of the country, of establishing Houses of Refuge in places threatened with Cholera, for the reception, not of the first persons who might take the disease, but of the other inhabitants of the same houses or rooms with those patients, whose services might not be necessary for taking care of them. In these Houses of Refuge, the persons known by experience to be the most likely to form the first series of cases in that town or district, may be lodged, kept in pure air, regularly fed, preserved from cold, and other frequently concurrent

* British and Foreign Review, January 1854, p. 298.

† See *e.g.* the cases noticed by the present author, as to the introduction of the disease in Belfast, Campbelltown, Banff, Dollar, and Arbroath, British and Foreign Medico-Chirurgical Review, January 1854, p. 12 *et seq.*, and Appendix, p. 298.

causes of the disease, and watched and treated immediately on the first symptoms showing themselves.

The author referred to the Reports of the London Board of Health, as furnishing statistical evidence of the importance of this precaution. They had information as to 1691 persons taken into such Houses of Refuge from rooms where there were patients in cholera, of whom only 33 became affected with cholera, and 10 died. He had himself been informed, in Edinburgh, in Glasgow, and in Oxford, of 1010 persons, during different epidemics, admitted from rooms where the disease existed, into such Houses of Refuge, of whom 40 took the disease, and 15 died; and comparing these statements with the accounts furnished at various places where the disease had shown itself, and such precautions had not been taken, or were not availed of by the people concerned, he considered the statistical evidence of the usefulness of this precaution against the formation of "tainted districts," as quite conclusive.

He stated further, that he had great hopes of the successful application of statistical evidence to establish the proposition lately made the subject of experiment in Germany, in consequence of a conjecture first hazarded by Liebig, and which, if established, would go far to explain all the strange anomalies as to the extension of this disease; viz. that this *virus*, like the Cadaveric poison, exciting erythematic inflammation already noticed, or the *Sausage poison*, from which a great mortality has been witnessed on different occasions in Germany, is developed during the decomposition probably of the *rice-water stools* in cases of cholera, but only *during a certain stage*, or during a certain mode of this decomposition, perhaps especially in dry air, and disappears when the putrefaction has reached a certain stage, or when it is taking place in some other mode. He referred to the curious experiments of M. Thiersch at Munich (Medical Times and Gazette, Nov. 25, 1854), made on mice, with whose food very minute portions of this matter from the intestines of cholera patients, dried and afterwards dissolved in water, were mixed, with the effect of producing the usual symptoms of cholera—poisoning in 30 of 34, and death in 12 of these, provided that the matter used was taken during days from the second to the ninth after its separation from the body of the patient, but not if taken during the first or after the ninth day. A repetition of this experiment he thought would be adequate to establishing this proposition statistically; and he referred also to observations by Dr. Budd, in letters published in the 'Association Medical Journal' from October 1854 to March 1855, especially his third letter, as affording strong ground for the belief that the usual mode of communication is simply by healthy persons using the same privies or close stools as the sick; and that the diffusion of the disease in certain places in England had been prevented by simple precautions for isolating the first patients affected with cholera in this respect, and especially where pains were taken, by the use of chlorides or otherwise, effectually to destroy the matters passed from their bowels during the disease within a few hours after their being passed.

Lastly, the author referred to numerous statistical proofs collected by himself and others, of the influence of the great social disease, poverty, on the health of all nations, and particularly on the extension of epidemic continued fever; and especially the Reports of the Irish Poor Law Commissioners, and of the Board of Supervision in Scotland, the former published since 1848, the latter since 1845, in proof, so far as the statistical experience of laws in force only since those years can go in establishing principles, that the apprehensions so strongly stated by Dr. Chalmers and others, as to the injurious effects on the character of a people, therefore on their numbers, and ultimately on their destitution itself, to be expected from any attempts to render their legal provision against destitution effective, are quite unnecessary; simply because statistical facts in this inquiry, as well as others, have shown that the prudential motive rightly stated by Mr. Malthus and others as the true check to population, is more truly effectual in people who are protected from the extremity of destitution, than in those whose characters are brutalized by privations.

The facts stated in official Reports by the Board of Supervision in Scotland, and in the Reports of the Poor Law Commissioners in Ireland, which he regards as the most valuable in this view, are—

1. That in Scotland, although the sums expended on the legal relief of the poor have risen since the time when he first brought this subject before the public, from £140,000 to £500,000 a-year, and the number of poor-houses from 4 to 62, yet the whole number of persons requiring to be inmates of these asylums, in July 1853, *i. e.* eight years after the new poor law came into operation, was less than 6000 in a population of 2,800,000, one half of whom belong to parishes in which poor-houses exist.

2. That although the whole number applying for legal relief increased greatly, as was to be expected, after the new law took effect, yet that number came to its maximum as early as 1849, when the whole number of registered poor was 106,400, and had *declined* to 99,600 in 1853, the latest year of which he had the return.

3. That there is no indication of increase of profligacy or recklessness of conduct during the operation of this improved law; but on the contrary, in some large towns of Scotland at least, of an improvement in the manners and habits of the people.

4. That in Ireland, where the redundancy of population, fostered, as he believed, by neglect and total want of legal provision prior to 1847 (when the existing poor-law was passed), was such that the famine of 1848 had really been fatal to a considerable portion of the population, we have as satisfactory evidence as could be desired, that the condition and habits of the existing population have been improved, notwithstanding that nearly one-eighth of them owed their lives to the legal provision; and of these facts he offered the following proofs:—The First Annual Report of the Commissioners, published in 1848, when the number relieved *daily* in this way was not less than 1,000,000, after stating that "a very large proportion of these were by these means, and by these only, daily preserved from death by want of food," adds, as a "*hopeful and satisfactory fact beyond all doubt or question*," that "the peasantry are showing that they are *not* disposed to rely either on charitable funds or *poor-rates* for their future subsistence." And the Eighth Annual Report, published this year, after stating that the demand for agricultural labour had improved universally throughout Ireland, and the usual rate of wages per day had risen from 4*d*., 6*d*., or 8*d*., to 1*s*. 6*d*., 2*s*., and 2*s*. 6*d*., no doubt in consequence of the diminution of the population, adds, that "they have ascertained that between 1849 and 1854, considerably more than 200,000 young persons of both sexes have left the workhouses in Ireland, and *not returned* to those asylums," notwithstanding "that the workhouse dietaries are greatly in advance of the ordinary cabin diet;" that there are "visible signs of an improved condition of life in the appearance of the peasantry in all parts of the country, more especially in their clothing;" and further, as more recent reports published in the newspapers attest, that in September 1855, the Irish workhouses were "completely emptied of paupers capable of doing any kind of work in the fields;" that in the Union of Athlone at that time only 452 paupers were receiving relief, where some few years ago there were above 6000; and that where the rates in some of the electoral divisions had been as high as 8*s*. and 9*s*. in the pound, the highest in that Union for the next twelvemonth will be 2*s*. 9*d*., and some as low as 4*d*.

These facts, and along with them the total absence of any complaints of epidemic fever, the author stated as evidence,—not that the former distress, and enormously redundant population in Ireland, and in some parts of Scotland, where there had been no poor-rates, and where fever had been most prevalent, had been owing merely to that circumstance,—but that the introduction of poor-rates into a country where such indications of redundant population and destitution exist, while it would afford much more security to the poor, and lay the burden much more equitably on the higher orders than any voluntary system of relief could do, would be found *no impediment* to the operation of any such causes, whether dispensations of Providence, or legislative regulations, as might improve their condition, moral and physical, and foster independence of character among them.

On an Improved Mode of Keeping Accounts in our National Establishments. By Lady BENTHAM.

On the Physiological Law of Mortality, and on certain Deviations from it, observed about the Commencement of Adult Life. By Prof. A. Buchanan, *M.D., University of Glasgow.*

I. The object of the first part of this memoir was to determine the normal course of mortality as affected by age alone, without reference to other circumstances.

What we name the law of mortality is not a simple law, but a compendious expression, by which we denote the operation of various laws, physiological, physical, and moral. Of these, the physiological laws are so uniform in their operation, that they impress certain characteristic features upon the law of mortality, according to age, which are observed amidst all the diversities which it exhibits under varying circumstances, physical and moral.

Of the physiological laws subordinate to the general law of mortality, the principal by far is the *law of natural decay*, which regulates not the human organism alone, but every organism, animal and vegetable, fixing the limits of its period of existence. This law must not be supposed to operate only in cases of extreme old age. Every child at birth contains within it the elements of its own decay; so, that although placed in the most favourable external circumstances, and exempted from all noxious influences, the series of organic actions in which life consists would come spontaneously to a termination; and this takes place at all ages, as we infer from seeing health decline, and a fatal disease declare itself, without the intervention of any external cause known to be hostile to human life.

The law of infantile mortality, again, depends upon causes of a different kind. The principal of these is the transition from uterine to independent life, which occasions a great change in all the actions of the bodily organs, and in the conditions and circumstances in which they are carried on; whence many infants perish in the transition, from the conditions necessary to the former mode of life being interrupted, while those necessary to the latter are not established with sufficient promptitude, or only imperfectly established. At a later period the mortality is kept up by the delicacy and vascularity of the tissues, the great excitability of the nervous system, now first exposed to irritation, the great size of the head, and the unequal development of other organs.

The mortality of early infancy is exactly similar in kind to the mortality (if that name can be applied to the destruction of embryonic life) attendant on the transition from ovarian to intro-uterine life, when a still more complete revolution takes place in all the actions of the system, and a new series of relations to the maternal organs is established. The destruction of life which ensues is greatest at first, and gradually diminishes as the new adaptations are effected.

To these physiological laws the uniformity in the course of mortality corresponding to age is to be ascribed; for whatever deviations occur in different communities from a difference in external circumstances, the general direction is the same in all, marked by a great excess of deaths, gradually decreasing, in early life; a similar excess, gradually increasing, in advanced life; and a comparatively low rate of mortality in the intermediate period.

Of the external causes which occasion the diversities in the law of mortality in different communities, there are some which may be named *conspiring causes*, as they act in conjunction with the physiological causes above-mentioned, and magnify their effects; while there are others of an *interfering* kind, that disturb the physiological results. To the latter class belong those causes that operate solely, or with peculiar intensity, at certain periods of life. Thus, a war occasions devastation among the young and strong, and disturbs the normal course of mortality. Causes, again, which operate more equably at all ages are of the conspiring class, for the physiological state of the body, varying with age, assists or resists their action. Thus the extremes of temperature tell chiefly on the infirm bodies of the young and old, while persons in the vigour of life resist their influence.

Of the law of mortality resulting from these causes, as it is observed in England, the most prominent characters may be expressed in general terms by saying, that human life is most secure at 13 years of age, and that as it recedes from that point towards either term of existence, it becomes less secure in a ratio which is constantly increasing.

The best mode of exhibiting the law of mortality, according to age, in its details, is by means of tables or diagrams indicating the ages at which the deaths in a large community, where the number of the people is known, have been observed to take place. The most useful tables of this kind for physiological purposes exhibit the same number of individuals entering on each year of life, and in the earlier years upon lesser periods, and determine the proportion of them which disappear by death in each year or lesser period.

The following Table, computed from a table of a different form, published in the Fifth Report of the Registrar-General for 1843, exhibits the law of mortality which prevails in England for a sufficient number of ages to show its general course,—diminishing gradually till 13 years of age, and gradually increasing after that age:

Years.	Deaths in 100.	Years.	Deaths in 100.
1	14·631	35	1·087
2	6·169	48	1·508
3	3·300	60	2·733
6	1·428	70	5·892
8	·934	75	8·605
10	·659	80	12·487
11	·555	85	17·936
12	·519	90	25·441
13	·500	95	35·555
14	·597	100	36·000
20	·793	105	50·000
24	·871	106	100·000
29	·977		

The numbers in this Table denote the average mortality for a whole year; but during the greater part of life no great error arises from employing the same numbers to denote the relative rates of mortality for any lesser periods in the same year, although, strictly speaking, each number in the Table belongs only to one such period, and all the rest have numbers either above or below that in the Table. This difference is so great in the first years of life, that separate observations require to be made to determine the rate of mortality at different parts of them. The following table of this kind stops short where it becomes identical with the former table, from its being unnecessary to distinguish the different rates of mortality at different parts of the same year. The numbers, properly speaking, denote the deaths at each age out of 10,000 children in 3·65 days, or the hundredth part of a year:—

First week	240·1	Second half-year	12·1
Second to fourth week	80	Third ditto	10·7
Second month	35·3	Fourth ditto	7·7
Fourth ditto	21·9	Third year	3·3
Sixth ditto	16·2	Sixth ditto	1·4

For indicating these minute differences a diagram is much superior to any Table; for every term in the Table merely denotes the length of a single ordinate to the "curve of mortality," and when a sufficient number of terms have been obtained to admit of the accurate delineation of the curve, every other ordinate to the period to which it corresponds can be readily found.

II. The second part of the memoir, to which the first was intended as an introduction, was devoted to the consideration of certain anomalies in the course of mortality that present themselves at the commencement of adult life.

The anomalies in question were first pointed out in Mr. Finlayson's Report on the Mortality among the Government Annuitants, published in the year 1829, a Report of great interest, as exhibiting the law of mortality that prevails among "the highest and most affluent orders of society" in this country. Among them the mortality in the male sex exhibits this peculiarity:—starting from 13 years of age, the point of greatest security of life, the mortality increases till the age of 23, after which, instead of continuing to increase, it decreases till the age of 34, and then it increases at so slow a rate that at the age of 48 it is still somewhat less than at 23. The rates of mortality at these remarkable epochs are as follows, contrasting them with the corresponding rates in the table given above:—

Age.	Rates of Mortality. Annuitants.	Average.
13	·574	·500
23	1·507	·871
34	1·170	1·087
48	1·487	1·508

These results have been confirmed and generalized by M. Quetelet, from the statistical returns for the kingdom of Belgium, the only difference being, that it is from 24 to 30 that the mortality is observed to diminish. Quetelet ascribes the great mortality at 23 or 24 to the violence of the passions at that age; and he holds that the same results occur among females, although obscured by the increased mortality among them at a later age, from dangers peculiar to the sex.

If these views of M. Quetelet be correct, the course of mortality just described ought not to be considered as anomalous, but, on the contrary, as the regular course of mortality resulting from the constitution of human nature, of which the passions form an essential part. The preponderance of statistical evidence, however, is on the opposite side of the question. The strongest by far is that of the Registrar-General, as given in the table already quoted, which shows a progressively increasing mortality from 13 years upwards, both on the average and among males alone. The same progression is exhibited in Mr. Milne's table of mortality for Sweden and Finland, and in Mr. Ansell's tables of the mortality among the members of the Friendly Societies throughout England.

If, again, the course of mortality exhibited in Mr. Finlayson's tables be regarded, not as normal, but as exceptional, it is clear that some other cause for it must be sought than one of universal operation,—the influence of passions inherent in human nature. A more probable cause the author held to be one which has no existence in childhood, and scarcely in boyhood, but which comes into operation at the commencement of active or independent life, from about 14 to 25 years of age, arising somewhat earlier among the poorer classes, and later among the wealthy; and among the latter existing exclusively among males, and attaining a much more formidable height than among the poor. It is at this period that children, who had been previously provided for by their parents, are called upon to provide for themselves. They had previously been nourished like branches on the parent stem; they are now severed from that stem, and if they fail to take root or to derive nourishment from the soil in which they are placed, they speedily decay. It is exactly so with young men on first establishing themselves in the world. We then see the effects of neglected education, vicious habits, bad dispositions, and ungovernable passions, which render them unable to avail themselves of resources within their reach; but we see also what is more to be deplored, the effects of over-population and of other political causes which tend to straiten subsistence, and thus prevent the rising generation from obtaining a footing in society. It is this struggle, or rather the anxiety, fatigues, dangers and privations attendant upon it, that are the true causes of the increased mortality which marks the commencement of adult life. This was illustrated by the increased mortality that takes place among young medical men between 22 and 30 years of age. Now, the government annuitants were placed in early life in circumstances not dissimilar; and the effect of these circumstances in producing the irregular course of mortality among them is well seen by contrasting it with the mortality regularly increasing with years observed among the members of friendly societies, according to Mr. Ansell's tables; for the circumstances of the latter were less conducive to health and comfort than those of the former, with the exception of the important circumstance, that the latter, as members of a friendly society, were not only able to maintain themselves, but to make a provision for a time of sickness, or a posthumous provision for those related to them in the event of death.

To illustrate the course of life and rates of mortality among the lower orders of society, reference was made to Mr. Neison's 'Contributions to Vital Statistics,' derived, like the work of Mr. Ansell, from the records of the friendly societies of England. The conclusion was, that while there is among those following certain employments an increase in the rate of mortality, there is not among them, generally, any such increase in the rate of mortality at the commencement of adult life,

as to indicate such a difficulty as that which exists higher in the social scale, of obtaining a position in society; but that, to counterbalance this, there are sudden and repeated augmentations of the rates of mortality occurring at irregular periods, and produced most probably by the pressure of numbers and the varying demands for labour, as well perhaps as by circumstances not well understood in the nature of particular employments. Thus, among agricultural labourers the mortality comes to a maximum at 23, and declines to a minimum at 30, just as among the Government annuitants. Among country workmen (not labourers) there is a maximum at 19 and a minimum at 25, and another maximum at 30 and a minimum at 32. Among miners there is a first maximum at 22 and a minimum at 29, and a second maximum at 34 and a minimum at 37. Among clerks, the first maximum is at 28 and the minimum at 35; the second maximum is at 44 and the minimum at 47. Among plumbers and painters the first maximum is at 18 and the minimum at 25, the second maximum at 33 and the minimum at 33. Among bakers, there are three maxima, at 18, 31, and 49, and three minima, at 22, 38, and 54. Among the female workers the course of mortality is very anomalous, decreasing from the earliest period till 24 years of age, and then increasing till 28 and decreasing till 33.

On a Mechanical Process, by which a Life Table commencing at Birth may be converted into a Table, in every respect similar, commencing at any other period of Life. By Professor A. BUCHANAN, *M.D., University of Glasgow.*

The process consists in the use of a *calculating diagram,* which performs, mechanically, all the calculations required; and can be made to answer the four following sets of questions by mere inspection of the diagram and the life table annexed to it.

1st. Of 10,000 persons entering upon any year or month of life, it tells the number which will survive at any subsequent period, or conversely.

2nd. Of 10,000 persons entering on any year or month of life, it tells at what subsequent period any per-centage or less given number will survive.

3rd & 4th. It will answer the same two sets of questions, giving the results not in the number of survivals, but in the number of deaths.

It is thus not only true that the diagram converts the life table, on which it is based, into a life table having the same radix but commencing at any given subsequent period of life, but it bestows on all of these tables properties which the original table does not possess; for it gives its indications either in terms of the deaths, or of the survivals, out of the original number of persons entering on any given period of life.

The diagram by which these calculations are performed is a right-angled triangle, so drawn that one of the sides forming the right angle is perpendicular, and the other horizontal. The perpendicular side or base is divided into 10,000, or any other number of equal parts corresponding to the radix of the table; and from the points of division a series of horizontal lines are drawn to the opposite, or long side of the triangle, each tenth line being more prominent, so as more readily to catch the eye. The radical number of the table is inscribed on the margin opposite to the top of the base, and the successive terms of the table are placed below it, at unequal intervals, so that each indicates the number of divisions of the base opposite to it, counting from the bottom; and on the same line is marked also the year of life to which the term corresponds. The horizontal side of the triangle is also divided into 100 equal parts, and from the points of division a series of perpendicular lines are drawn intersecting the horizontal ones, each tenth line being made more conspicuous.

The diagram being thus constructed, the mechanism by which the calculations are effected is exceedingly simple. A thread or fine cord is attached to the vertex of the triangle, and the cord being stretched to any point of the base, whatever be the age marked at that point, it converts the table on the margin into a life table commencing at that age.

The principle upon which the results depend, is that the cord, being a line drawn from the vertex of the triangle to the base, divides the base and all the lines parallel to it into proportional parts, and we have therefore the lower segment of the base to the lower segment of any parallel, as the whole base is to the whole parallel. Now these are exactly the four proportionals involved in the questions proposed above

for solution; and the lengths both of the entire lines, and of the segments of them cut off by the cord, are given by the tabular numbers on the margin. To obtain the answers, in terms of the number of deaths, instead of the number of survivals, it is only necessary to count the divisions of the base from the top, instead of from the bottom, for which purpose twenty prominent decimal figures, of a different colour from those of the table, will suffice; and instead of reading the last proportional from the table, it is read at the same point from the other series of numbers.

On Prevailing Diseases of Sierra Leone. By R. Clarke.

On some of the results deducible from the Report on the Statics of Disease in Ireland, published with the Census of 1851. *By* John Coldstream, *M.D., Edinburgh.*

The report in question was presented to both Houses of Parliament, by command of Her Majesty, during the session of 1854. It contains special reports on the numbers and condition of the deaf and dumb, of the blind, of lunatics and idiots, of lame and decrepit, of the sick in workhouses, hospitals, prisons, and asylums, and a general report on the total sick in Ireland on the day of the census of 1851. These reports are illustrated by thirty-nine elaborate statistical tables. Additional details are given in an appendix of seven tables; five of which show the number and diseases of the sick at their own homes, and in public institutions, in Ireland generally, and in each of the four provinces; the sixth shows the same arranged in counties, cities, and towns; and the seventh shows the same arranged according to the ages of the sick. These reports and tables are founded on the facts ascertained in reply to queries issued along with those for the census. Their examination and reduction appear to have been executed with the greatest care. The whole form a rich mine of valuable information.

The diseases specified in the tables amount to 109 in number; they are systematically arranged. In each table showing the disease of a province, there are headings to distinguish the patients in towns from those in the country; and headings for the sick in infirmaries and asylums, and in workhouses. By an examination of one of the tables in the Appendix, one can ascertain at a glance the numbers affected with each of the 109 specified diseases in any of the counties or chief towns of the kingdom.

104,495 cases of diseases and injuries of all kinds are reported as having existed throughout all Ireland on the day of the census. Of these 7284 were of blindness, 5074 of insanity, 4848 of idiocy, and 4337 of deaf dumbness, forming together more than one-fifth of all the diseases reported upon. Of zymotic or epidemic, endemic and contagious diseases, there were 34,998 cases, of which 13,777 were of fever, and 6716 of dysentery. Of 69,497 cases of sporadic diseases, 24,522 were of the nervous system, 534 of the circulating organs, 10,509 of the respiratory organs, 4511 of the digestive organs, 289 of the urinary organs, 693 of the generative organs, 8822 of the locomotive organs, 7167 of the tegumentary organs, 10,394 were diseases of uncertain seat, 1224 were cases of injury by accident; and of 832 cases, the nature was not specified. The 24,522 cases of diseases of the nervous system included 21,543 cases of blindness, insanity, idiocy and deaf dumbness. Of the proportions borne by these to the general population, the following summary is given:—

Deaf and dumb...	1	person in	1265	of the community.
Blind	1	,,	864	,,
Insane	1	,,	1291	,,
Idiotic	1	,,	1336	,,

Of persons returned as idiots, 2666 were males, and 2240 were females. Generally the proportion of idiots is smaller in the civic than amongst the rural population; while it is quite otherwise with lunatics, the proportionate numbers of whom are nearly twice as great in the towns as they are in the country. It is noted that 3562 idiots are at large, 202 in asylums, 13 in prisons, and 1129 in workhouses. So that only about one-fourth of the idiot population is in any way cared for.

The results of the inquiries made regarding the occupations of lunatics and the apparent causes of their malady are tabulated in the report. Of 404 persons of the professional class, affected with lunacy, only 40 are reported as having apparently been injured by moral causes, and 54 by physical causes. In the same class, grief amongst females, and excessive study amongst males, are the most injurious causes of lunacy; whilst amongst shopkeepers, tradespeople, and agriculturists, reverse of fortune and grief are most commonly productive of disease.

The cases of fever were more than double the number of those of any other disease. They were very unequally distributed throughout the provinces.

In Leinster ...	there were	3056 cases	in a population of	1,672,174
In Munster ...	,,	6107	,,	1,857,244
In Ulster......	,,	1917	,,	2,011,786
In Connaught.	,,	1541	,,	1,012,006

It thus appears that in Ulster there were nearly one-third of the proportional number of persons affected as compared with those of Munster, and little more than one-half of the Connaught numbers.

The report enables us also to compare the prevalence of fever in the cities and towns with its prevalence in rural districts; and such a comparison shows that, in certain parts of the island, there is but little difference in this respect between the town and country; in others, that the numbers are considerably greater in the towns. For instance, in the town of Waterford, with a population of 33,900, there were 176 cases of fever reported; while in the country (exclusive of the town), with a population of 164,051, there were 282 cases of fever reported, instead of 880, as there would have been, had the same proportions between the population and fever existed in the country that did in the town.

It seems very desirable, that what was in this matter done for Ireland in connexion with the last census, should be done for England and Scotland in connexion with the next census.

An Analysis of some of the Principles which regulate the Effects of a Convertible Paper Currency. By Count D. Frölich.

On Decimal Arrangement of Land Measures. *By* Peter Gale, *A.M., Dublin.*

The plan proposed is of the simplest character, and in accordance with the existing system. In fact, there are involved only two changes, both beneficial in themselves, productive of important effects, and yet of easy modification with the existing system. The first of these changes is to get rid of the fractional part of the perch, by reducing it from $5\frac{1}{2}$ to 5 yards. As the easy conversion, however, of the local measures of the United Kingdom is of great practical importance, a matter heretofore altogether overlooked, no change is proposed in our acreable divisions. The acre then which will result from this proposed diminution of the perch, and which for distinction's sake may be called the Imperial acre, will stand thus:—

	Square Yds.		Square Yds.
1 Square Perch	25	instead of	$30\frac{1}{4}$
40 Square Perches, 1 Rood, or	1000	,,	1210
4 Roods, 1 Acre, or............	4000	,,	4840

The first fact to be noticed is the simplicity of this acre above all existing ones. Both the rood and acre consist of whole numbers, admitting of easy decimal calculation. Secondly, the proportion between the existing local measures will be rendered easy; a matter of more importance than is generally supposed, and which would be effectually prevented by the decimal arrangement recommended by the Commissioners of 1842. In the conversion of the several local measures into statute measure, the fractional nature of the statute or English perch acts most injuriously; for as each of these acres contains the same number of perches, their respective proportion must be as the square of the perch; and as the statute perch of $5\frac{1}{2}$ yards squared makes $30\frac{1}{4}$ square yards, in every case where the statute acre is the object of comparison, to get rid of the fraction we must multiply it by 4, and

consequently increase the proportion to the same extent. The proportion, therefore, between the Irish and the statute acre is as 121 to 196, whilst that between the Irish and the proposed imperial acre is only as 25 to 49; and in the same manner the Cunningham bears to the statute acre the ratio of 121 to 144, and to the imperial that of 25 to 36, and the Chester acre to the statute acre the ratio of 121 to 256, and to the imperial acre that of 25 to 64. The Scotch acre admits of a still greater reduction, for it may be taken at the ratio of 484 to 615 to the statute acre, and to the imperial acre only that of 80 to 123. The proposed imperial acre is capable of scientific division, as well as of general application.

The second change proposed is the substitution of a mile of 2000 yards for 1760, an improvement borne out by the recommendation in their report of the Commissioners in 1842. The term mile is derived from *mille, thousand*; or one thousand military paces constituted the ancient Roman mile, each pace therein consisting of two steps. If, therefore, we put fathoms for paces, and yards for steps, we come at the same constituent members as the original mile. A fathom is defined as that portion of the sounding-line which a man can extend between his outstretched arms. This mile might then be popularly described as measured by 1000 men standing in a straight line, with hands joined, and arms extended in a horizontal position. This mile also will admit of a decimal division into furlongs. A fact of very great importance is, that by this arrangement we acquire all the advantages of a strict decimal scale, without its recognized defects, namely, not permitting of subdivision into quarters or eighths without fractional parts. For though it is true that $2\frac{1}{2}$ furlongs is not a convenient division for a quarter of a mile, yet this defect is compensated by the fact that 100 perches, or 500 yards, represent the same quantity. The effect of this second change upon the proposed acreable arrangement may now be stated. A square mile, either English or geographical, is the basis on which all our statistical calculations are founded. The English square mile makes 640 English acres. The proposed imperial square mile will make precisely 1000 acres, and every 1000 square miles one million of acres. The adoption of such a system would place our land measures at least on a scale commensurate with our civilization and the scientific requirements of the age.

The author gives examples of the advantage to statistics of these arrangements, and finally discusses the question of the increased scale upon which it is proposed to conduct the Ordnance Survey of Scotland, under the Treasury Minute of the 18th of May 1855, as presenting a favourable opportunity for such a change. The scale proposed, 25,344 inches, does not admit of subdivision in our existing measures. By enlarging this scale 1-25th, and adopting the proposed imperial measure, this practical inconvenience would be obviated, and a decimal proportion maintained.

On the Laws of the Currency in Scotland. By J. W. Gilbart, *F.R.S.*

The author commenced by observing, that by the "currency of Scotland," he means the notes issued by the banks in Scotland, and by the "laws of the currency," he means the uniform operations of those circumstances which regulate the amount of notes kept in circulation.

In this paper he proposed to consider,—first, the constitution of the banks by whom the notes are issued; secondly, the banking operations by which the notes are put into circulation; thirdly, the laws which regulate the fluctuations in the amount; and fourthly, the effects of the Act of Parliament passed in the year 1845, for regulating the currency in Scotland.

Under the first head he observed, that all the banks of issue in Scotland are Joint Stock Banks; that they have numerous partners; that they have large paid-up capitals; that they are few in number; and that they have many branches.

Under the second head, he noticed the operations on current accounts, on deposit receipts, on cash credits, and the system of exchanges between the banks.

Under the third head, he stated it to be one law of the currency in Scotland that the amount is not the same every year, but varies in amount from year to year, from causes which are specified; another law is that the amount is not the same in every month during any year, but varies in each month; and a further law, which is uniformly exhibited every year, is that the amount is the lowest in the months or March and the highest in November: another law is that the amount of notes in

circulation under £5 is much greater than the amount of notes of £5 and upwards. It is also a law, that the amount of small notes circulated in the agricultural and highland districts is higher in proportion than in districts more wealthy and more densely populated; and finally, it is a law, that the fluctuations in the amount of small notes do not correspond from month to month with the fluctuations in the amount of large notes.

After discussing the causes of these respective changes, the author proceeded to the fourth head.

He considered that the law of 1845, for regulating the circulation of Scotland, was more favourable than the law of 1844 for regulating the circulation of England, inasmuch as not only were the small notes continued, but the banks were allowed to issue beyond their certified amount on holding an amount of gold equal to the amount of the excess; and also, if two banks of issue should unite, the new bank is allowed to issue to the amount previously issued by both the united banks. From these and other causes the circulation of Scotland has continued to increase since the year 1845, while that of the Private and Joint Stock Banks of England has considerably declined. The banks are indeed put to the expense of bringing gold from London, but they endeavour to reimburse themselves in some degree by increased charges on London payments and cash credits, thus proving that restrictions upon banks are taxes on the public. The measure, however, has not inoculated the people of Scotland with the love of a gold currency, a feeling which would be disastrous for Scotland. The gold when required is quietly brought down from London, is quietly locked up in the bank vaults, and when no longer wanted is quietly sent back again. Upon the whole, the author thinks that the Scotch bankers are pretty well satisfied with the Act of 1845; and were an English statesman to ask them the question once addressed by a minister of commerce to a body of French merchants, "What can I do to serve you?" they would probably make the same reply, "The greatest service you can render us is to let us alone."

On the Localities of Crime in Suffolk. By* J. GLYDE, *Jun.*

In Suffolk, the greatest amount of crime is committed in the villages, not in the large towns.

On the Fluctuations in the number of Births, Deaths, and Marriages, and in the Number of Deaths from Special Causes, in the Metropolis, during the last Fifteen Years, from 1840 *to* 1854 *inclusive. By* WILLIAM A. GUY, *M.B., Cantab., F.R.C.P., Prof. For. Med. King's College, Physician to King's College Hospital.*

The objects of this communication were,—1st, to reduce the facts contained in the "Summary of births, deaths, and causes of deaths in London, for the fifteen years, 1840 to 1854, compiled from the weekly returns, and published by authority of the Registrar-General," to a form admitting of comparison of one year with another, and useful for purposes of reference; and 2nd, to invite attention to the most remarkable results of such a comparison of year with year, and especially to the fluctuations occurring in the mortality from special causes.

For the accomplishment of the first of these objects, the author made use of the "Summary" just referred to, which also states the estimated number of the population of the metropolis for each of those years. All therefore that remained to be done, to reduce these facts to a form admitting of comparison, was to equalize the length of the several years by reducing them to the common standard of 365 days, and the number of living persons to one million. The tables in the Appendix are the results of this twofold work of equalization. They display, for the fifteen years 1840 to 1854 inclusive, *the number of births and deaths in a million persons living during a year of* 365 *days.*

After some explanatory statements, in reference to the return of births, deaths, and marriages, and some observations on the statistical education which the registrars, coroners, and medical profession were receiving at the hands of the Registrar-Gene-

* Since published in the Journal of the Statistical Society.

ral during the fifteen years embraced in the returns, and the consequent alterations and improvements in the returns themselves, the author showed that the year 1845, in which blank forms of certificates of the causes of death were first issued, formed the commencement of an æra of greatly improved registration; so that before the year 1848 it is reasonable to suppose that the returns of the causes of death would have attained to all the accuracy of which they are susceptible in the hands of the present race of medical men; and that neither fashion, nor new theories, nor increasing knowledge, would have materially affected them in so short a period of time. In the longer period of fifteen years, even in the absence of statistical instruction, some changes would doubtless have taken place in medical opinions as to the causes of death; but as these changes would not affect the diseases most easy of diagnosis, such as typhus fever, the eruptive fevers, diarrhœa, &c., the tables would still be found in many parts, throughout the whole period embraced in them, to furnish the materials of a just comparison.

In carrying out the comparison of year with year, the author proceeded to comment upon the several tables forming the Appendix to his paper, in their order, beginning with the births, deaths, and marriages, and ending with the more considerable of the special causes of disease; his chief object being to direct attention to the *fluctuations* in the mortality from special causes, employing as a *measure of mean fluctuation* the quotient obtained by dividing the sum of all the successive differences between year and year, whether in excess or defect, by the number of those differences, and then reducing that quotient to a per-centage proportion of the average of all the years, and also the greatest and least numbers in each series of facts, reducing the difference between them, or in other words, *the Extreme Fluctuation*, to a per-centage proportion of the maximum numbers.

Having thus explained the meaning of the terms "Mean Fluctuation," and "Extreme Fluctuation," the paper proceeds to a review of the several tables, making appropriate comments upon each, beginning with the births, deaths, and marriages.

The births, which, on an average of the fifteen years, amount to 32,028 in the million, have fluctuated between a minimum of 30,348 and a maximum of 33,736, the mean fluctuation in the intervening period having been nearly 2 per cent. The deaths were subject to much greater fluctuation. They ranged from a minimum of 20,925 to a maximum of 30,078, the average being 24,864; and the mean fluctuation was 9·51, or little short of 10 per cent. The highest and lowest numbers occurred in the two consecutive years 1849 and 1850. The marriages, for the shorter period of thirteen years, presented an amount of fluctuation intermediate between that of the births and of the deaths. The average number of marriages was 10,136; the extremes were 9408 and 10,966; the mean fluctuation 3·75, and the extreme fluctuation 14·20.

The extreme fluctuations in the numbers of births, deaths, and marriages, follow the same order as the mean fluctuations. Thus the mean and extreme fluctuations in the births were, respectively, 1·95 and 10·04; in the marriages 3·75 and 14·20; in the deaths 9·51 and 30·38.

The births were uniformly in excess of the deaths, and even the fatal year of 1849 was no exception to this rule. The excess varied from 1838 in that year to 11,086 in the year following.

From the Table showing the deaths at the three ages 0 to 15, 15 to 60, and 60 and upwards, it appeared that the greatest mean and extreme fluctuation occurred from 15 to 60; the least mean fluctuation from 0 to 15, and the least extreme fluctuation from 60 years of age upwards. The occurrence of the least mean fluctuation in persons under 15 years of age was, perhaps, scarcely to be expected.

The Table showing the deaths in five districts of the metropolis presented some results worthy of notice. In the east districts alone the maxima and minima coincided with the maxima and minima of the total deaths. In the south districts, the maximum number occurred in the same year, 1849, but the minimum number in the year previous, instead of in the year following. In the west and central districts, again, the minima coincided with the minimum of total deaths; while the west and north districts were distinguished by the occurrence of the greatest number of deaths in the last year of the series, 1854.

But the most interesting fact shown by this table was the excessive mortality and high rate of fluctuation prevailing in the southern districts of the metropolis.

The mean number of deaths per million inhabitants were as follows:—

West Districts	3676 deaths.	
Central ,,	4402	,,
North ,,	4670	,,
East ,,	5435	,,
South ,,	6535	,,

It will be seen that when the southern districts are contrasted with the most healthy group of districts (the west), their mortality is as 6535 to 3676; and when compared with the districts subject to least fluctuation (the north), their mean fluctuation is as 21·50 to 5·67, and their extreme fluctuation as 48·20 to 18·58. In this character of fluctuation, therefore, the north and the south occupy the two extremes. The only cause which seems capable of explaining a difference so remarkable and so considerable is the prevalence of epidemics on the south side of the Thames, and the comparative immunity from them of the inhabitants of the higher districts on the north side. If sanitary improvements should be found, after a term of years, to have had little effect on the rate of mortality, or the prevalence of epidemics, in these districts south of the Thames, every discouragement ought to be thrown in the way of the extension of buildings in so low and unhealthy a locality.

The author of the paper then went on to examine the deaths from special causes, beginning with *the deaths from seventeen principal groups of causes.* These seventeen groups admitted of being divided into two classes, the one characterized by a high, the other by a low, or moderate, mean fluctuation. At the head of the first class stands the group of zymotic diseases, followed in order by several groups of diseases having a mean fluctuation varying from 31·24, in the case of zymotic diseases, down to 11·26, in the case of diseases of the respiratory organs. The second class, comprising a larger number of groups, and ending with diseases of the brain, nerves, &c., has a mean fluctuation from 10·71, in the case of death from old age, down to 3·50 in the case of diseases of the brain, nerves, &c. Of the whole seventeen groups, the zymotic diseases are those which present the highest mean rate of fluctuation, and the diseases of the brain, nerves, &c. the lowest.

The group of zymotic diseases, which in the reports of the Registrar-General comprises eighteen separate maladies, the author extends so as to embrace Quinsey and Carbuncle.

As the principal diseases belonging to this zymotic class are remarkable for the readiness with which they may be distinguished, even by non-professional persons, they are not likely to have been affected by improvements in registration or in medical science; and as they are also of great importance in their relation to the public health, the more considerable of them, placed, for the most part, in the order of their fluctuation, are brought together into one table:—

	Maximum.	Minimum.	Mean.	Mean Fluctuation.	Extreme Fluctuation.
1. Cholera	6209	15	780	153·97	99·76
2. Influenza	562	35	110	95·45	93·77
3. Small Pox	890	87	399	69·92	90·22
4. Scarlatina	2132	354	899	59·51	83·40
5. Measles	1122	249	575	41·74	69·92
6. Dysentery	163	38	85	34·12	76·68
7. Carbuncle	36	1	9	33·33	97·22
8. Hooping Cough	1217	582	857	31·04	52·17
9. Diarrhœa	1522	246	747	29·45	83·83
10. Typhus	1600	615	951	23·55	61·56
11. Purpura (Scurvy)	36	6	17	23·53	83·33
12. Erysipelas	260	113	164	17·68	56·54
13. Quinsey	53	22	34	17·65	58·49
14. Thrush	170	63	103	10·68	62·94
15. Croup	229	130	167	8·98	43·23
16. Ague	15	5	10	26·40	66·66
17. Remittent Fever	52	9	30	22·13	82·70
18. Infantile Fever	26	9	17	20·00	65·38
19. Syphilis	76	11	43	15·11	85·52
20. Hydrophobia	3	1	0·73	38·35	66·66

There are three diseases in this list which scarcely admit of being considered separately, inasmuch as the mortality set down to two out of three of them is evidently swollen by cases really due to the remaining one. These diseases are diarrhœa, dysentery, and cholera—diseases to which the events of the last few years have lent an unusual interest. The subjoined table shows the number of cases entered each year under these three heads, together with the aggregate numbers, and the fluctuations to which they are subject singularly and collectively. The table is divided into two parts, consisting each of seven years (with an intermediate year, 1847). In the first septennial period we had no visitation of epidemic cholera, while in the second period we suffered from two such visitations; so that by comparing the two periods we shall know what excess of mortality is due, in the second period of seven years, to two visitations of Asiatic cholera.

	1840.	1841.	1842.	1843.	1844.	1845.	1846.	Average of the 7 Years.	Mean Fluctuation.	Extreme Fluctuation.	1847.
Cholera	33	15	62	44	32	21	108	45	71·11	86·11	52
Diarrhœa	246	248	369	428	348	407	1022	438	35·62	75·93	886
Dysentery	38	42	79	139	62	48	74	69	52·17	72·66	138
Total	317	305	510	611	442	476	1204	552	37·68	74·66	1076

	1848.	1849.	1850.	1851.	1852.	1853.	1854.	Average of the 7 Years.	Mean Fluctuation.	Extreme Fluctuation.
Cholera	292	6209	55	90	67	351	4269	1619	168·12	99·11
Diarrhœa	857	1522	812	960	897	921	1290	1037	31·82	46·65
Dysentery	150	163	78	72	63	65	70	94	21·28	61·35
Total	1299	7894	945	1122	1027	1337	5629	2750	111·09	88·02

It will be seen that the total mortality in a million of persons living in the metropolis from English cholera, diarrhœa, and dysentery, in the first seven years (1840 to 1846 inclusive,) in which there was no visitation of Asiatic cholera, was 3865, or an average of 552 per annum; while in the last seven years (1848 to 1854 inclusive) the total mortality was 19,253, or an average of 2750. The excess of mortality, which may be presumed to have been due to Asiatic cholera in the last seven years, was therefore 19,253 —3865, or 15,388; and the annual excess 2750 —552, or 2198. This excess must be understood to consist of the additional deaths from the three diseases, cholera, diarrhœa, and dysentery, and not of the addition made by the visitations of Asiatic cholera to the mortality from all causes.

The deaths from cholera, diarrhœa, and dysentery combined, in the first seven years, will be found to have reached their maximum in the year 1846, the hottest year of the fourteen, and with one exception (1841) the year of the greatest rainfall. This was also the second year of the potato failure, and food was dear.

The paper then goes on to show that an intimate relation exists between a high mortality from these diseases and a high temperature, and that no other atmospheric condition which can be expressed in figures bears any similar relation to the mortality from these causes.

If we assume the yearly average of 552 deaths from cholera, diarrhœa, and dysentery, during the seven years from 1840 to 1846 inclusive, to be the true average from these three analogous diseases, and consider them as one disease, we shall be in a condition to point out the order of importance of the several maladies comprised in this group of zymotic diseases. The disease which commits the greatest ravages among the population of the metropolis is typhus fever. The deaths set down to this cause amount to 951 in the million of inhabitants. Scarlatina comes next in order, as the cause of 899 deaths. Hooping-cough occupies the third place, and gives rise to 857 deaths. Measles proves fatal to 575 persons; cholera, diarrhœa, and dysentery collectively, to 552 persons; small-pox, to 399; croup, to 167; erysipelas, to 164; influenza, to 110; thrush, to 103; syphilis, to 43; quinsey, to

34; remittent fever, to 30; infantile fever and purpura, each to 17; ague, to 10; carbuncle to 9; and hydrophobia, to less than 1 in the year.

A very interesting group of diseases (tubercular diseases) is remarkable for the moderate mean fluctuation to which it is subject. It comprises one very important disease, namely pulmonary consumption, which shows a remarkable degree of steadiness, whether we test it by the mean or by the extreme fluctuation. This fatal malady of the young adult proved fatal, in the fifteen years comprised in the table, to a maximum of 3941, a minimum of 2645, and an average of 3230 in the million, being little less than a seventh part of the total deaths at all ages, and more than a third part of the deaths from 15 to 60. The average number of deaths from this fatal disease is, as nearly as possible, 13 per cent. of all the specified causes of death at all ages, and 39 per cent. of the deaths from 15 to 60 years of age.

Dr. Guy finished his communication by stating that the object with which it had been taken in hand was sufficiently answered by the publication of the five tables in the Appendix, which would, he thought, be found very useful for purposes of reference; and he promised to take an opportunity of turning to another account the figures contained in his tables.

On the Agricultural Labourers of England and Wales, their Inferiority in the Social Scale, and the means of effecting their Improvement. By John Locke.

Mr. Locke, after a few preliminary remarks, referred to the education of the labourers, which, he remarked, should be adapted to the peculiar circumstances of each class. Such instruction as was suitable to the labourer's subsequent position in life was generally omitted in rural schools; and while the chemist had developed the principles of agriculture, and the mechanist facilitated its operations, they lost sight of the fact, that the human instrument of production was left uncultured in the acquisition of ideas relating to the nature of his future employment. The deficiency, too, was aggravated by children leaving school too soon, before their intelligence was thoroughly awakened as to their duties in life. Hence resulted pecuniary losses to employers; for they could neither expect earnestness in intention nor system in performance, when a man understood not the reason of what he did, while his very ignorance extinguished all rational ambition of improving his lot in life. Let them now see how far the efforts of Lord Brougham and others had been productive of practical results. According to the Parliamentary returns of 1818, there was then in day schools 674,883 scholars, and 477,225 in Sunday schools; now, extending their inquiry to 1854, during which interval the population had increased 54 per cent., the number of day scholars then amounted to 2,144,378, and of Sunday scholars to 2,407,642. Out of twelve agricultural counties in England, the most favourable attendance of children at day schools was above the standard proportion of one in eight of the population, and the most unfavourable, one in ten. In North and South Wales and Monmouthshire, the proportion was still lower. Mr. Locke, after expressing his opinion in opposition to charity schools, except in cases of absolute necessity, and also on the dwellings of the labouring community, which he thought might be greatly improved, referred to the opinion which, he said, of late years had been gaining ground, that the anomalies of the poor law require an extension of the area of taxation. Mr. Locke concluded his paper by remarking that, until œconomy was made available for profit, it would not be thought of by that section of the community, whose wages being barely adequate to support existence, afford neither motive nor result to prospective industry and ingenuity. When the principle of hope is extinguished, all improvement—moral, intellectual, and physical—is interrupted at the very outset.

On the Influence of Factory Life on the Health of the Operative, as founded upon the Medical Statistics of this Class at Belfast. By A. G. Malcolm, *M.D.*

After some preliminary observations relating to the importance of the linen manufacture to Ireland, the origin of flax-spinning machinery, and the agitation respect-

ing factory labour, Dr. Malcolm proceeded to draw attention to the influence of factory life as founded upon the medical statistics of the largest factory town in Ireland, with the view of showing that there are still injurious results due to factory employment. He premised a brief description of the processes through which the flax passes from the rough state to the yarn, in order that the exact amount and nature of the employments in flax-spinning factories may be fully comprehended. He also alluded to a few interesting points in connexion with the intimate structure of the flax fibre, whereby it was shown that silica enters largely into its composition, and also that in other respects its elementary fibre was essentially firm and unyielding; these and the foregoing subjects were illustrated by several diagrams and specimens of the flax itself, as it appears after undergoing the different processes. The *à priori* conclusions as to the capability of the different branches of factory employment to induce disease were then severally detailed thus:—1. The influence of the flax and tow dust on the organs of respiration. It was shown that these particles are necessarily a source of irritation, and that their continued inhalation must sooner or later induce organic disease. 2. The position of the worker: this influence is manifested primarily in articular affections, and secondarily in inducing thoracic and gastric maladies. 3. The high temperature of the spinning-rooms: this cause, combined with the moist atmosphere, and in addition the sudden transitions of temperature to which the worker is exposed, conspire to disorder the respiratory functions, and afterwards predispose to a more general contamination of the system. The author next submitted the results ascertained by statistical laws based on actual experience.

Belfast contains about 112,000 inhabitants, of whom about 36,000 belong to the operative class. Of this latter number, about 11,000 are factory workers, a sufficient and extensive basis upon which to rear conclusions respecting the objects of this paper. The tabular returns brought forward were made out from three sources; viz. 1st, the examination of 2078 female workers, by means of certain queries indicating the particular employment, the age, the time at mill-work, the condition of health, and, as far as could be ascertained, the medical history, including the number of times off work on account of ill health, the duration of past serious illnesses, and, as far as possible, the nature of the illnesses themselves. 2nd. Returns from the Belfast General Hospital records, showing the relative number of factory workers, and the nature of the diseases for which they were admitted into hospital. 3rd. Similar returns from the registers of the six dispensary districts into which Belfast is divided, showing the number of workers treated, and the diseases under which they suffered. 4th. The author's experience as medical attendant for several years of public institutions, which afforded abundant opportunities and a personal inspection of the workers at the factories. The results of the evidence thus furnished were compared with the returns of disease amongst the entire population for whom medical relief has been provided by hospitals and dispensaries, that is amongst that section of society of which the factory operatives form a part. 1st. The examination of the 2078 female workers, omitting the tabular statements, gives the following general result. Among the "spinners," it was found, as expected, that headaches, gastric ailments, and complaints of the limbs predominated. The "preparers" complained of these affections in a less degree. 2nd. The hospital cases showed a large proportion of injuries, cutaneous diseases, affections of the chest, especially phthisis, and of the limbs. In comparison with the returns of all cases admitted into hospital for a period of several years, it was ascertained that an increase of the general average was observed among the workers in the following affections, viz. diseases of the skin, injuries, pulmonary consumption, uterine diseases, nervous maladies, and affections of the limbs. 3rd. The dispensary returns give the following result upon a basis of 2053 mill-workers: affections of the chest, digestive organs, the skin and uterus, also fevers, syphilis, and affections of the limbs greatly predominated. Compared with the general average of 35,039 cases as they occurred in the districts, we find that diseases of the chest, gastric ailments, uterine and syphilitic diseases, fever and affections of the limbs are in higher proportion amongst the mill-workers.

The hospital returns in reference to the diseases of "hacklers," extending over a number of years, elicited the fact that chest diseases were in the high ratio of 30 per cent., and that diseases of the skin and affections of the limbs were also in consider-

able number. The paper concludes with a statement of the means which the author considers are calculated to reduce disease to a minimum and improve the comfort and condition of the operative:—1st. Increased provision for ensuring full ventilation of the different apartments, whereby an equal temperature and the freest change of atmosphere would be obtained without being subject to the control or whim of the operative. Horizontal shafts, communicating with a large air-expelling fan, were recommended as absolutely necessary for the brackling and carding apartments; the opening of the sashes when required should be regulated *en masse*, and not, as at present, here and there, whereby drafts and minor currents are produced. 2nd. To prevent the entrance of the flax and tow particles into the respiratory passages, some means, acting like the ordinary respirator or the natural moustache, is imperatively required. 3rd. In order to counteract the injury to the young spinners consequent upon the present mode of conducting the employment, a suitable mill-dress, to be put on on entering the factory, would be most desirable; during work, the outer ordinary clothing might be hung up in a dry room, to be resumed at the close. 4th. It would be the interest as well as duty of the employer to encourage all proper means of enabling the operatives to spend their evenings in a manner calculated to improve their mental condition, and thus rendering them more disposed to view their position in a true light, and to give freely and fully a fair day's work for a fair day's wage. By refining the taste, the operative becomes armed with a counteracting power against the degrading though seductive attractions of vicious habits, and the employer receives the benefit with interest in the better fulfilment of the operatives' duty, and the greater degree of confidence which becomes established between them.

Juvenile Delinquency—its Principal Causes and Proposed Cure, as adopted in the Glasgow Reformatory Schools. By the Rev. A. K. M'Callum, *M.A., Governor of the House of Refuge, Glasgow.*

In the outset, the writer showed that crime being one of the social problems of the age, in order to diminish the number of our criminals, we must begin by the reformation of our youthful offenders. He then enumerated in detail the causes of juvenile delinquency in Glasgow. The principal of these were—

I. *Depraved Parental Influence.*—He represented the disastrous effects of intemperance upon the family, and showed that the child is led by the profligate example, and sometimes precept, of his parents, to the commission of crime, and is thus brought under the lash of the law. He found, out of 286 boys now in the House of Refuge, 72 who attribute their fall either directly or indirectly to the bad conduct of their parents. He mentioned, as another prolific source of crime—

II. *Corrupting Associates.*—He stated that there are hundreds of adepts in vice throughout the city who make it their business to inveigle young persons, and compel them by threats, or encourage them by rewards, to steal. That these young victims, however, soon set up for themselves, and carry on their depredations on their own account. That the number of youths corrupted in this way annually is very great; and that all public works, and society in general, are heavy sufferers. That these are chiefly young persons inured to crime by repeated recommittals to our gaols; and that, among the boys of the House of Refuge, there were 152 who trace their ruin principally to these bad companions.

III. *Wee Pawns and Marine Stores* were another source of evil. They are the favourite haunts of the beggar, the thief, the drunkard, and the juvenile delinquent, from the universal nature of the articles they receive. That the young person was confirmed in his nefarious traffic from the facilities afforded by these places for the disposal of his booty. That the whole system of pawnbroking houses should be thoroughly revised, and a severe penalty inflicted on any one who received articles from YOUNG *persons under any pretence whatsoever.* He stated that—

IV. *Shows and Minor Theatres* were, beyond comparison, the most prolific sources of juvenile crime. That these places are whirlpools, into which, when our youth are once drawn, their destruction is almost inevitable. The writer himself visited some of these places in company with two officers, kindly furnished by the Superintendent of Police. The scene he witnessed will not bear description. From

300 to 400 young persons were huddled together in one of them, three-fourths of whom, according to the testimony of an experienced officer, lived by thieving. The scene for the night was a fair representation of what usually occurred; and yet the licentious inuendos introduced, the low profligate character of the songs sung, and the whole moral atmosphere, was charged with a pollution which could not but exert the most deadly effect on all that we hold sacred and virtuous. There were 173 boys in the House of Refuge who stated these pests as the principal cause of their being led astray.

As a substitute for these places, he suggested the throwing open of botanic gardens, museums, and works of art and industry, at the lowest charge to the working classes. The opening of public parks, to furnish abundance of pure air and recreation. The encouragement of cricket, bowling, and other athletic games, by offering premiums. The furnishing of lectures on scientific, industrial, and other popular subjects. The opening of schools of design, and *free* public libraries; and the supplying of abundance of sound, substantial, and cheap education to the very poorest of the people. To encourage education, he suggested that our capitalists, mill-owners, and other extensive employers, *should take no youth into their works except he be furnished with a certificate of education*, which ought to be a condition of leaving school. That this would be a sufficient motive for the most neglectful parents to see their children educated. That the law affecting pawns should be remodeled. That such minor theatres and shows as are found conducive to immorality should be suppressed. That the sale of ardent spirits should be restricted. That the houses of the working classes should be made more comfortable, by extending the benefits of Dunlop's admirable Act; and that by the home enjoyments thus secured, the increased intelligence, the taste for elevating and ennobling pursuits, most, if not all, of the debasing habits now prevalent, at once our social bane and disgrace, would speedily disappear.

The writer then proceeded to mention certain

Remedies.—That short imprisonments had totally failed in reforming juvenile delinquents, was self-evident. Some, while in confinement, purpose an amendment of life; and, were they then taken by a friendly hand, might be rescued; but when, on the day of liberation, they meet with bands of their former associates in crime, can we feel astonishment that these resolutions will be overcome? This is the uniform testimony of those who have the amplest means of knowing, and experience confirms the fact. In Glasgow prison, during last year, according to the Report for the Prisons of Scotland, the re-committals were—665 once; 363 twice; 247 three times; 190 four times; 135 five times; 191 from six to ten times; 71 from ten to twenty times; and 26 from twenty to fifty times. Edinburgh is no better. In that gaol there were—re-committed, 1001 once; 544 twice; 234 three times; 226 four times; 142 five times; 375 from six to ten times; 337 from ten to twenty times; 218 from twenty to fifty times; and 23 upwards of fifty times.

Thus we see that short imprisonments only aggravate the evil they are designed to cure. The reformatory element, then, must predominate in our treatment of the young. But the remedy must be *commensurate* with the disease. We would have every juvenile delinquent brought before the police court for the *first* time, to be handed over to his parents, or guardian, if he has any, who should be charged to keep him from infringing the law. Upon being convicted a *second* time, he should be sent to the Reformatory School, at the expense of his parents, and kept there till his majority, or till such time as the Directors of the House were satisfied that he would conduct himself, if discharged, as a proper member of society. The objection will be raised against this treatment, that it interferes with the liberty of the subject, and that the punishment is out of proportion to the crime committed. To this it is answered, first, that there is no *punishment* at all inflicted, the object being solely the child's welfare; and, secondly, that society has rights and privileges which should ever be held sacred; thirdly, that there is no injury done to the person who has transgressed the rights of society, should that society declare that a certain period must elapse before his full privileges be restored to him; and, lastly, to the objection that parents will become indifferent to their children, when they know they will be cared for, and that children will be found to commit crime to qualify them for admission;—the time proposed to keep them in the Reformatory,

and compelling parents to support them, is a sufficient answer. None will seek to qualify themselves under such conditions. Ample experience in the Glasgow Reformatory confirms this.

In a Reformatory Institution there should exist a correspondence, as near as practicable, between the condition of the boys in the house, and what will be his actual condition in life. This will prevent a reaction. There should be no finery, either in their dress or food. All should be plain, substantial, and conducive to health. They should be made to learn their trade thoroughly, as this will give them a great superiority over those whom they will meet with when they go out into the world. The principal *remedies* he would suggest, are adopted in the Glasgow Reformatory Schools, a brief history of which was given. The subject of juvenile delinquency was impressed, at an early period, upon many of the public-minded and benevolent citizens of Glasgow. In the year 1836, a subscription was set on foot to erect, by voluntary contribution, an institution for the reformation of the dangerous classes. The appeal was met with the usual liberality which distinguishes the merchants of Glasgow. Upwards of £20,000 were collected. A piece of ground, about five acres, to the east of the city, occupying an elevated position, was purchased, and a handsome erection raised thereon. The house was opened for the reception of inmates on the 17th day of February, 1838, by the Very Reverend Principal M'Farlane. In its early stage it met with many difficulties. Its present prosperity is greatly owing to the enlightened and comprehensive measures of the Honourable Board of Commissioners, and the indefatigable exertions of the Convener, James Playfair, Esq. The Houses of Refuge were licensed last year, under the Youthful Offenders Act, 17th and 18th Vict., cap. 86, as Reformatory Schools. In the boys' house, three objects are sought to be accomplished for every inmate admitted;—to send him out with a good education, a good trade, and a good character. The institution aims at educating the *whole* boy, physically, morally, intellectually, and socially.

I. *Education.*—In the school, reading, writing, arithmetic, grammar, geography, music, scientific and scriptural knowledge, are taught. The time is divided into two divisions, fore and afternoon, with four classes in each. While the one division is taught at school, the other attends their trade. Thus weariness and listlessness are unknown in either, and as much progress made in both, as if only one were carried on at a time. The boys are found very ignorant when admitted. Out of 286 boys, 79 upon admission could read tolerably well, 110 could read little words, and 97 did not know the alphabet.

II. *Industry* obtains a prominent place in the house. Idleness is the bane of our juvenile population, and almost invariably leads to crime. It is therefore found a vitally important element to train the boys as much as possible to the usual trades carried on in society—in short, to make the house a little world of its own. At present, farming, tailoring, shoemaking, smith-work, coopering, bookbinding, printing, joining, and wood-splitting, are the principal occupations conducted in the house. More are in contemplation. The gross return from work executed during the past year was £3300 1*s.* 1*d.*, and the net proceeds, after paying from this sum the material for the work, the salaries of the superintendents of the trades, and journeymen employed to instruct the boys, was £614 2*s.* 3*d.*

III. *Moral Training.*—The house, with its present number 286 (which from additions and alterations now in progress will soon accommodate 450), is one large Christian family, with the Governor and his wife acting in the room of parents. The law of love pervades the youthful community. A moral tone, through Bible and kindly training, influences the whole. Force and restraint are unknown. A newly admitted boy, after preliminary training separately under the immediate care of the Governor, is by degrees permitted to associate with the rest, and obtain his full privileges. Those thus admitted are absorbed into the habits and feelings of the rest, and soon moulded by them. The sympathy of numbers is found most beneficial. At the close of each day, three marks—one for obedience, one for truthfulness, and one for industry—are given to each boy by his master, according as he has behaved. Thus he daily writes out the certificate which is to determine the length of time he is to be detained in the house. Confidence is placed in the boys. In the summer they enjoy excursions down the Clyde to the Botanic Gardens, &c.,

and in no instance has this privilege been abused. Of 229 boys dismissed during the last five years, after the most rigid examination, we can discover but *nine* cases who have fallen into the hands of justice. From 80 to 90 per cent. are doing well. The following are some of their occupations, viz. 30 sailors, 6 soldiers, 19 tailors, 16 shoemakers, 14 farmers, 2 mechanics, 3 iron-founders and moulders, 4 wrights, 5 message-boys, 3 shop-boys, 3 brassfounders, 1 baker, 1 carver and gilder, 4 office-boys, 3 carters, 1 shopkeeper, 1 clerk.

Conclusions.

1. That our great cities are the centres of crime; and that many incitements to juvenile delinquency there existing, might, through judicious interferences, be greatly modified.

2. That gaol punishments, instead of reforming, invariably demoralize juvenile delinquents.

3. That to benefit youthful delinquents, and successfully induce parents to contribute to their support, they should be sent to Reformatories till their majority, giving power to the directors of such places to send them out, on being satisfied that they would do well.

4. That the law of love and kindness, combined with intellectual and moral training, never fails in reclaiming youthful offenders, and making them useful members of society.

5. That the experience of many years in the Glasgow Reformatory Schools, proves the reformability of from 80 to 90 per cent. of juvenile delinquents.

6. That, in an economical point of view, prevention is better than cure; the gross cost of a boy in the Glasgow Reformatory being £13 per annum, and, deducting his earnings, about £10.

TABLE I. Showing the Number of Boys admitted and disposed of from 1st July 1854 till 1st July 1855.

Boys in House 1st July 1854		232
Boys admitted from 1st July 1854 till 1st July 1855		87
Boys disposed of from 1st July 1854 till 1st July 1855		69
Of these there were sent to Canada and the United States	10	
Sent to the Navy	7	
Boys for whom situations have been procured	41	
Boys who left the House irregularly	9	
Boys who died in the House	2	
Boys who returned of their own accord		5
Average number of Boys in House during the year		237
Boys in House 1st July 1855		250

TABLE II. Showing the average age of Boys when they began to steal, age when admitted into the House, and age at present (1st July 1855).

Age of Boys .... years	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total.
No. when admitted into House	3	5	6	15	36	26	56	57	44	22	11	2	3			286
No. with present age in House	...	...	1	2	8	16	28	30	64	63	40	20	9	3	2	

Average age when they began to steal, from 9 to 12 years.

TABLE III. Showing the time the inmates have been in the Institution.

	One year and less.	Two years.	Three years.	Four years.	Five years.	Six years.	Seven years.	Total.
No. of Boys	143	41	44	23	18	15	2	286

Table IV. Showing the character of Parents, and whether dead or alive, of 286 Boys now in the Institution.

Number of boys one or both of whose parents are (or were when alive) drunkards	124	
Number of boys whose father or mother deserted or were unknown to them	48	
Number of boys whose parents are both dead	61	
Number of boys whose father is dead	79	
Number of boys whose mother is dead	42	
Number of boys whose parents are both alive	56	
		286

Table V. Showing the principal incitements to Crime, and the nature of the offences for which they were convicted.

Number of boys who stated the shows and minor theatres as the principal cause of their being led astray	173
Number of boys who were encouraged to dispose of stolen articles in little pawns, rag and marine stores	147
Number of boys who trace their ruin to bad companions, especially young persons who have been in prison	152
Number of boys who assigned their parents' misconduct and hunger as the cause, &c.	72

Table VI. Showing the state of Education when admitted into the House, and their present state, of 286 Boys now in the Institution.

On Admission.	Boys who did not know the alphabet	97	
„ „	Boys who could only read little words	110	
„ „	Boys who could read tolerably well	79	
	Total		286
„ „	Boys who could read, write, and count a little .. 48		
Present State.—	Boys who can read but little words	59	
„ „	Boys who can read tolerably	86	
„ „	Boys who can read well	141	
	Total		286
„ „	Boys who are writing	227	
„ „	Boys at grammar and geography	134	
„ „	Boys at arithmetic	185	

Table VII. Showing the character of 229 Boys discharged from the House during the last four years, viz. from 1st July 1851, till 1st July 1855.

Number of boys whose history could not be traced	13	
Number of boys who died since leaving the house	10	
Number of boys who relapsed into crime and were convicted	9	
Number of boys who have not been convicted, but are not very steady	14	
Number of boys who are doing well	183	
Total		229

Giving 80 per cent. of those who are known to be doing well, irrespective of those whose addresses are unknown.

Table VIII. Showing the Number of Boys admitted and discharged from 1st July 1850, till 1st July 1855.

Admitted.		Discharged.	
1850–51	71 boys	1850–51	34 boys
1851–52	64 „	1851–52	47 „
1852–53	46 „	1852–53	45 „
1853–54	49 „	1853–54	34 „
1854–55	85 „	1854–55	69 „
	315 boys.		229 boys.

Average of admissions 63 boys. Average of discharges 45⅘ boys.

Table IX. Showing the countries to which the boys at present in the Institution belong.

Born in Scotland		222
Of these there were born in Glasgow	160	
Born in England		7
Born in Ireland		56
Born in other countries (America)		1
Total		286

Table X. Showing the Trades conducted in the House, and the average Number of Boys employed at them.

Tailoring	62
Shoemaking	81
Wood-splitting	105
Farming	24
Joining	14
Smiths	10
Coopering	9
Bookbinding	12
Printing	4
Various occupations	36
	357

Table XI. Showing return from Boys' Labour, and Expenditure for one Year, from 1st July 1854, till 1st July 1855.

	Gross.			Net.		
	£	s.	d.	£	s.	d.
Gross amount of work done	3300	1	1			
Net Proceeds, after paying for the material and wages of tradesmen				614	2	3
Gross expenditure	2905	13	1			
Net expenditure, after deducting profit on work, which sum is paid from share of assessment for Boys' House and board for Sunday				2291	10	10
Gross cost of each boy per annum	13	0	0			
Net cost, after deducting his share of earnings				10	0	0
The above includes all expense but house-rent. Previous to the rise of provisions the net cost was				7	10	0

Table XII. Showing the Number of Officers and Tradesmen employed in the House of Refuge for Males.

Governor		1
Teacher of School and Assistants		4
Clerk and Storekeeper		1
House officers		2
Superintendent of	Tailoring and Tradesmen	7
,,	Shoemaking and Tradesmen	6
,,	Farming and tradesmen	2
,,	Joining	1
,,	Smiths' trade	1
,,	Coopering	1
,,	Bookbinding	1
,,	Printing	1
Gate and doorkeepers		2
Female servants		5
Total		35

INDUSTRIAL SCHOOLS.

TABLE XIII. Showing the Number of Boys and Girls admitted and disposed of, from 1st December 1853, till 1st December 1854.

	Boys.	Girls.	Total.
In School on 31st December 1853	155	85	240
Admitted during 1854	101	56	157
Deserted but re-admitted	18	..	18
Left during the year	161	75	236
Remaining on 31st December 1854	113	66	179
Employment was found for	49	27	76
Removed by parishes and sent home to relations, &c.	23	46	69
Deserted	85	1	86
Died	4	1	5

On Measures relating to the adoption of the Family and Agricultural System of Training in the Reformation of Criminal and Destitute Children. By JAMES M'CLELLAND, *Esq., F.E.S., President of the Institute of Accountants, and Actuary of Glasgow.*

The author gave a sketch of the origin and progress of Institutions for the reclamation of the fallen, which from time to time have been established throughout various countries in Europe, under the enlightened guidance of some of the best and most philanthropic men of the day. One of the first pioneers in this great work was M. de Fellenberg of Hofwyl*, near Berne, a name known throughout the civilized world for his unwearied interest taken in the cause of education. About the year 1810 this gentleman instituted, on his own estate at Hofwyl, a labour school, which began with teaching and training beggar boys and criminals. The high principle with which he set out was, by the training the children received at his hands, to attempt to create an improved race of men, according to his means, and thus to infuse new blood into the veins of society. To do this he resolved to isolate his pupils, to guard them from contamination with any outward form of vice, and, on their attaining the requisite education and training, to send them into the world as models for their associates to follow. He then hoped that, like so many loadstones, they would attract others around them, and thus be the means of doing good to others as he had attempted to do good to them. In this way this little leaven might, he thought, in process of time leaven the whole social lump. The peasantry were at first offered the benefit of his institution, but they had a feeling of distrust in his plans, and, unwilling to lose the labour of their children, they either refused or omitted to come forward to adopt the views he had placed before them. Being a man of firm and undaunted resolution, he was not to be baffled by such an obstacle. His next movement was to try the beggar boys of his neighbourhood. He took this class even in their most neglected state of body and mind. Young criminals he did not refuse as his pupils, and this class of the "fallen" he fed, clothed, instructed, and trained, and instilled in them habits of industry, truthfulness, and order. The means he had at command for the promotion of his views were excellent. On his estate at Hofwyl M. de Fellenberg carried on extensive farming operations, and in this way advantage was taken for the development of his scheme, and the labour of the children made an accessory in promoting it. The author notices the valuable aid given by M. Vehrli in carrying out these noble ideas.

According to the report of M. M. Ruggett, the establishment was partially kept up by the labour of the children. This is estimated at half a kreutzer an hour, which is equal to the sixth of a penny, for the youngest child; a kreutzer and a half for the eldest, or one halfpenny; and one kreutzer for the middle class, or one third

* I have been reminded by a correspondent, Isaac Weld, Esq., Vice-President of the Royal Dublin Society, that the labours of Pestallozzi took the precedence of those of De Fellenberg. I am glad to have an opportunity of making this correction. No man of his time ever exercised so great and philanthropic an influence on his countrymen as was done by Pestallozzi. By his powerful mind, by his devotion, his example, and his labour, he gave an impulse to the elevation of all classes of society in Switzerland, while he helped to alleviate and improve the condition of the poor of the district in which he resided.

of a penny. The average of the yearly produce of each scholar is about £3 16s., and the average of yearly cost of a child, including labour and learning, and after deducting the value of the work, is about £5 4s. It thus appears that the cost of a child, including his own labour, is about £9 a year. This, however, does not include interest on the cost of the buildings, schools, dormitories, &c. These were of a very frugal and ordinary description, but not the less fitted for the work of reclaiming the child. This system of training under De Fellenberg, and the enlightened family he reared around him, continued for nearly forty years, and was the means of setting an example and instructing kindred spirits throughout all Switzerland. The fruits of his benevolent exertions are now seen, not only in the reclamation from ignorance and vice of many thousands of his fellow men, but in the impetus it ultimately gave to the foundation and promotion of other similar institutions in various parts of Switzerland.

The next example in point of date is that of Count von der Recke, member of a noble Prussian family. He renounced, like De Fellenberg, his station in life, and its accompanying pleasures and comforts, to devote himself to the education of poor, destitute, and fatherless children. At Dusselthal Alley, near Dusseldorf, about the year 1816, he commenced an institution and refuge for the destitute, following up the same views and principles as have been alluded to. The number of destitute children and others, together with servants and teachers, seems to have amounted at one time to 220 persons, among whom Von der Recke seems to have lived as a father, improving their minds, training their various talents, and, by the undeviating law of love, reclaiming the most vicious and the most destitute among the inmates. The Dusselthal school exhausted the strength and injured the health of its benevolent founder, and, after suffering from pecuniary difficulties, it is now partially supported by the inhabitants of Dusseldorf.

The next institution to which attention was directed is that of J. H. Wichern—a man originally in a humble position—of the village of Horn, near Hamburg. In the year 1833, Wichern and his mother resolved to devote their minds and labours to an attempt at the solution of the difficulty which besets all civilized life—the permanent reclamation of the lowest grades of society. With this end in view he acquired a small house in the village of Horn, near Hamburg, to which was attached about an acre of land. In this domicile he began his work, first with those unfortunates taken from the streets of Hamburg. These soon increased in number to fourteen, ranging in age from 5 to 18 years, and all versed in the practices and haunts of ignorance and vice; nearly all had been trained to beggary, theft, and untruthfulness; one of them had been convicted of 93 thefts, and yet had only reached his twelfth year. Their calling by day was beggary and theft, their domicile at night was under carts, in door-ways, or herding with the lower animals. These children found themselves of an evening sitting in the cottage, around a blazing fire, with the inmates of Wichen's family. According to the report of 1851, there had been created quite a village of children families; and besides the dwellings for them, there are workshops, wash and dyeing-house, printing office, bakehouses, schools, and chapel, &c. The institution has about 70 boys and 25 girls. They constitute four boy families and two girl families, ranging in age from eight to sixteen years.

During the period of almost thirteen years since the foundation of this establishment in 1833, a total number of 207 children, viz. 157 boys and 50 girls, have been received into it at the period of this report; 90 of these are still in the establishment up to the present time; therefore 117 have quitted the narrow circle of our pupils. Six of these have died at various periods; 111 remain, who have adopted some social calling, or at least quitted the establishment. To these 111 may be added six, who are, indeed, still living in our institution, but occupy there the position of apprentices, inasmuch as they are learning a trade for their future subsistence. These 117 stand thus in detail:—Restored to their parents, in order that the latter might complete the education of the children, or provide for their future maintenance, after confirmation.—In these cases, therefore, the institution has only taken a partial position: including the six received for one year during the year of the fire, 21; emigrated, 6; agriculturists, labourers, and gardeners, 5; seamen, 9; shipbuilder, 1; sailmaker, 1; carpenters, 2; joiners, 7; smiths and locksmiths, 6; coppersmith, 1; wheelwrights, 2; strapcutters, 2; tailors, 5; shoemakers, 6; weaver, 1; tinman, 1; plasterer, 1;

butcher, 1; coopers, 3; bakers, 3; lithographic printer, 1; grocer, 1; bookbinder, 1; printers, 5; student, 1; workmen without definite occupation, 8; female servants, 13; homeless (female), 1; in prison (1 woman and 1 man), 2; total, 117. Well may Wichern ask in his simple language, "What would have become of these 117 outcasts from society but for the hand extended to them by the Rauhe Haus?" M. Wichern goes into the detail of the labour performed by the children in carpentry and joiner work, in the tailors' shop in making and mending clothes, mattresses, pillows, &c., in the shoemaker's and at the wooden shoe manufactory, in wool spinning, in the bakehouse, and in a great number of minor branches of industry, including the work of bricklayers, painters, &c. The produce realized out of the labour and work performed by the children and their family fathers is thus given:—"The produce of the farm cannot be separately stated without entering largely into detail; suffice it to say that even the smallest harvest from garden or field is accurately entered in our books. We have carried home cabbages and vegetables of various kinds to the amount of 362 marks 13 schillings, fruit to the amount of 16 marks (our 4000 to 5000 fruit trees, many of which have been planted for ten years, have as yet produced little), 578 sacks of potatoes, 213 of oats, 10,000 lbs. of hay and grass, and 80 loads of dung. 6 pigs have been fattened, 4 calves slaughtered, and about 4000 quarts of milk delivered into the kitchen. The produce of the field and garden may be reckoned, according to the market prices, at 300 marks 5 schillings; the costs at 1685 marks 1 schilling; thus leaving a profit of 1324 marks 4 schillings, or about £88 12*s.* sterling."

The next institution to which special attention and consideration are called is that of M. Demetz, at Mettrai, in France, conducted under the title of the "Agricultural Colony." The principles adopted by Wichern in the care and management of his reformatory are here systematically and faithfully carried out.

From a report recently published, it appears the Mettrai School contains about 400 boys, arranged on the principle of being a collection of families.

The principle of the school instruction is, that the boy shall only be taught as much as the average of agricultural and other labourers require, viz. to read, to write, and to cypher. The more advanced boys are taught the elements of drawing and geography. The instruction is in all points made as individual and personal as possible. All the boys are taught music. Industrial training occupies a large portion of the day. It is a principle that the boys shall be continually occupied and thoroughly fatigued. There are about four hours allowed for meals, recreation, morning and evening prayers, dressing, &c. The rest of the day, with exception of one hour appropriated to instruction in the school, is devoted to labour. The accommodation, dress, and food of all the inmates, officers as well as boys, are of the plainest description. The whole establishment thus feels the effects of the benevolent mind of Demetz. "Since the first establishment of the institution in 1839 there have been received 521. The number of present inmates is 348, leaving a remainder of 173. Of these, 17 have died; 12 have been sent back to their prisons for misconduct; 144 have been placed out in various situations in the world. Of the 144 thus placed out, 7 have relapsed into crime; 9 are of doubtful characters; and 128 are conducting themselves to the satisfaction of the directors."

It appears that in the Mettrai school, if you shut out the first cost of the building, or the interest or rent, with the teachers' salaries, taxes, servants, &c., the gross annual cost of each boy is £20. Then his labour, in and out of doors, produces upon an average £8 a year, thus reducing the annual expense of the reformatory training of a child to £12; and as each child stays, on an average, three years and a half at the institution, the total cost will be £42. If we contrast the palace prisons of England or Scotland, with the modest requirements of the farm or agricultural system at Mettrai, the advantages of the œconomical system of bringing up the boys, and in working out their own human improvement, will be at once seen. At York Castle the cost of each cell is stated to be £1200. Other prisons vary from £120 up to £500. Pentonville has cost £161 per cell.

The author describes the further progress of the principles and methods of Dr. Fellenberg and his followers in Switzerland, and concludes by drawing attention to one inaugurated in Holland, about five years ago. It owes its origin and present efficiency to Prof. Suringer, of Amsterdam. This gentleman brought under notice

of his countrymen the neglected state of the criminal poor in Holland, and it was not long ere he obtained the countenance and support of many eminent and distinguished persons to his proposal for the erection of a reformatory for the fallen. M. Schuler, of Amsterdam, contributed 16,000 florins, which, with gifts of other friends, was sufficient to purchase an estate called Rysselt, near the town of Zutphen, and in the district of Gorssel, containing about 100 acres, and buildings on the land of sufficient capacity to cultivate it. Two of the royal family of Holland patronized the institution by each building a cottage to form a family house for the children.

Rysselt began with a dwelling-house, a farm of 100 acres, and separate cottages for the families of children. There were at the outset eleven children under a family father, M. G. J. Van Dyck; and a director, or head-master, M. J. W. Schlimmer, for twenty-five years a prison teacher at Rotterdam. At the end of the year 1851, there were 45 children, and the work was then conducted by four family fathers, and a master for the agricultural department. The great aim of the establishment is in the reclamation of the children, to develope their moral and religious feelings, to teach them the system of tilling the ground and gardening, to initiate them to a trade, by which in after life—independent of the then agricultural training—they may be able to gain an honest livelihood; to endeavour to eradicate or deaden the sinful dispositions, strengthening weakness of character, repressing and controlling angry feelings, and thereby helping to develope the good qualities inherent more or less in every child. To attain this end, systematic instruction is given in the simple elementary and practical principles of religion, and (independent of the farm-training in the open air and fields) by the common rudiments of knowledge taught in all schools, great attention being paid to the child's musical faculties as an important instrument of reform. They go four hours on an average each day to school, and when the time of year permits, are employed six or seven hours at field labour. The school hours are regulated by the seasons. In winter the education is given in the evening, in summer early in the morning and in the afternoon. Horn music or the bugle is found an efficient aid in promoting order and cheerfulness, giving life and animation to all around. It is employed as a signal for rising, for going to bed, and for school and labour hours. Military exercises form another branch of training, and half an hour is daily devoted to this object, sticks being used in place of guns. Field and garden labour, and work in the woods, are found to be of the utmost consequence: hence the chief business is the culture of land, gardens, and trees. The small number of teachers and family fathers does not admit of a variety of trades, as that would imply large outlay for the wages of experienced workmen. It is at present confined to carpentry and architecture. The boys helped to build the porter's lodge; also, a carpenter's shop, and a hut in which 60 boys can work wood. Two boys assist the baker, who is also a family father; a couple of boys are taught to shave; all are accustomed to darn stockings and to mend rents in clothes. They fill alternately the post of porter, and by turns serve at the family table, and keep the family house clean. Every morning the head-master, the farm-master, and the book-keeper (who is also a family father), and all the family fathers, assemble to direct the labours and work of the day; this is noted down and made known to the whole at the morning hour of muster. In spring and harvest, when speed is needed, the boys are all set to work, and make up, during wet and frosty weather, for lost hours at education. During the hours of winter, they are employed in mending tools, weaving and spinning, &c.

The results which seem fairly to flow from the facts contained in the foregoing narrative are:—1. That the union of labour, and especially agricultural labour, with learning, and constant occupation and work in the open air and field, are the best calculated to promote, in an efficient and œconomical manner, the steady and successful reclamation and reform of the majority of the criminal and destitute among the young. 2. That under the operation of the recent legislation upon reformatory schools, the course which should be recommended to be followed is to plant and encourage reformatories upon small farms, and, by following out the family system, to apportion the children in such small sections, or groups, as will be effectually managed (under a head teacher or director) by house or family fathers, apportioned in cottages upon the farm, fitted to contain each family, and living

continually under their care and control. 3. That to carry the work efficiently into operation, the director and house or family fathers should be thoroughly and practically trained to the calling, and should only be employed on their evincing, under a probationary test, their love for the work, and on giving proof of their intellectual, moral, and religious capacity for the calling. 4. That, from the foregoing views, it seems to follow that the erection and foundation of reformatory institutions within the precincts of cities or towns will not serve the end in view of the promoters with so much efficiency or œconomy as the adoption of the family system upon small farms; and that such institutions now situated in cities or towns should be gradually removed and located in districts of the country favourable in soil, situation and proximity to railways.

Remarks on two Lectures delivered at Oxford in Trinity Term, by the Professor of Political Economy, on the subject of a recent Paper by Mr. Newmarch, "*On the Loans raised by Mr. Pitt from* 1793 *to* 1801." *By* William Newmarch, *Hon. Sec. S.S.*

On the Emigration of the last Ten Years from the United Kingdom, and from France and Germany. By W. Newmarch, *Hon Sec. S.S.*

Five hundred thousand persons had emigrated annually during the last five years from Europe to America, of which 300,000 went from England, and 200,000 from central Europe. The population of Great Britain had increased 300,000 during this period; so that the entire increase of our population from natural causes had emigrated. This could not go on without materially interfering with the population and position of this country, although Dr. Farr thought it could do so. There was a Board of Emigration in France, somewhat similar to ours, and a decree of the Emperor made regulations corresponding to our Passenger Act. The French emigrants came chiefly from the Rhine districts. Our emigration was chiefly (60 or 70 per cent.) from Ireland. It was nearly self-supporting. It had raised the rate of wages greatly in Ireland. The reaction of this emigration was most beneficial; not only had the surplus population been removed, but a stream of money was flowing back in the shape of remittances. The emigration into the United States in 1854 was 460,000, of whom one-half came from Great Britain and the other half from central Europe. France has been but little affected by this vast emigration. In ten years (1844 to 1854) the emigration to the United States had been 3½ millions, and the population of that country had increased 37 per cent., which was three times the rate at which our population increased. Mr. Newmarch then referred to the great prosperity of our North American colonies, and the rapid rate at which they had progressed during the past ten years. In that period they had undergone changes, and assumed a position fraught with importance to this country. He next alluded to our Australian dependencies. The colony of New South Wales remitted £1,600,000 to this country in 1853, to promote emigration thither, and the other colonies had also remitted large sums for the same purpose.

Mr. Newmarch stated that the emigration of this country employed a fleet of 1000 ships, with a tonnage of 800,000. These vessels sought return cargoes, often at Calcutta, which had a good effect on the commerce of this country. They were the finest and largest vessels we had.

On "Equitable Villages" in America. By William Pare, *F.S.S., Dublin.*

There was founded, some years since, at Long Island, in the state of New York, what is called an "Equitable Village," under the distinctive title of "*Modern Times.*" Its origin is due to Josiah Warren, formerly of Cincinnati, Ohio, who claims to be the discoverer of a new theory of society now sought to be reduced to practice at "Modern Times" and other "Equitable Villages" in various parts of the United States of North America.

According to Mr. Warren, the following is the social problem, in all its branches, which has to be solved:—

I. The proper, legitimate, and just reward of labour. II. Security of person and

property. III. The greatest practical amount of freedom to each individual. IV. Economy in the production and uses of wealth. V. To open the way for each individual to the possession of land and all other natural wealth. VI. To make the interests of all to co-operate with and assist each other, instead of clashing with and counteracting each other. VII. To withdraw the elements of discord, of war, of distrust, and repulsion; and to establish a prevailing spirit of peace, order, and social sympathy.

And, according to him also, the following principles are the means of the solution of this social problem:—

1. Individuality. 2. The sovereignty of every individual. 3. *Cost* as the limit of price. 4. A circulating medium founded on the cost of labour. 5. Adaptation of the supply to the demand.

The author explained the views of Mr. Warren and his expositor, Mr. Andrews, on the theory and application of these principles; and especially referred his audience to a work by the latter, entitled "The Science of Society," published by Fowler and Wells, New York.

On a Plan for Simplifying and Improving the Measures, Weights and Monies of this Country, without materially altering the present Standards. By Lieut.-Gen. Sir C. Pasley.

On Decimal Accounts and Coinage. By Theodore W. Rathbone, *Esq.*

The author proposes a plan for the introduction of decimal accounts and coinage into this country, which claims the merit of involving the *minimum of change*, of disturbance of existing arrangements and habits, in accomplishing the object in view; and with the *maximum of ultimate result*, as regards the introduction of a *perfect* and *comprehensive* decimal system, and on principles equally applicable to weights and measures.

He proposes to change, *compulsorily, nothing but one single money of account—simply to adopt tenpence instead of twelvepence as our future coin, by rendering pence and tenpence hereafter our legal moneys of account*—leaving it entirely to the future experience, and to the decision of the public, to determine to what extent the pound shall be confined to the expression of large amounts, and its use discontinued in our ordinary everyday accounts; and further, whether any and what new coins of circulation shall be issued, as the present are worn out. Without interference with the present circulation, or any kind of alteration in the present value, of a single existing coin (the point as to which the poorer classes are most sensitively tenacious and subject to injury), and without the introduction of any one new—any incommensurable, not accurately exchangeable—coin (which is the fatal defect of almost every other mode of proceeding), and without any abrupt compulsory alteration of the present forms of account in the columns £ *s.* and *d.* (which is also an inevitable consequence of *every* other proposition that has been made)—the proposed *exchange of ten for twelve in one column* throws all our accounts up to the pound, all the accounts of the poorest and least instructed classes, into the most perfect and strictest possible, as well as the simplest and most intelligible, of decimal forms;—leaving it optional to continue the ruled columns, or adopt to any extent the decimal point—on *this* scheme unmistakeably indicating the units and tens*. Accounts beyond the pound in amount are likewise thus, in any case, at once relieved from the great inconvenience of the present complicated system—the *addition of the pence column duodecimally instead of decimally—in twelves instead of tens*; nor can any one who has had experience of the comparative convenience and advantages of the beautiful, confessedly perfect, decimal system of *France*, doubt that not only when legally required, but in all ordinary transactions, pence and tenpence would soon become universally our usual moneys of account—easily rendered as they ever would be into pounds by a number affording so many useful factors for mental and every

* One penny, decimally indicated on coins and in accounts, would be ·1; sixpence ·6; tenpence would be 1·0; twelvepence 1·2; thirtypence (the half-crown or three-franc coin), 3·0; a pound twenty shillings, or twelve pences, that is, 240 pence would be 24·0; the decimal and existing figures being identical.

other species of calculation, and corresponding so well with our present binary and duodecimal coins, as twenty-four*.

The correspondence of this form of decimal account with those of other countries, is also a consideration of the greatest importance, were it necessary to look beyond the immense benefits we should thus so easily, and with so little perceptible change or inconvenience of any kind, secure at home. Our ordinary accounts would be *identical in form* with those of France and a very large portion of Europe, but with the further important advantage, that, being based on an existing coin and established money of account (our old English penny), we should at once secure, and bring into operation, the two moneys of account united by the strictly decimal tie, and ascertained by extensive experience of this and other countries, to be those in amount most convenient and practically useful; whereas France, after a struggle of more than half a century, and with the aid of penal enactments such as this country would scarcely tolerate, has to this day been unable entirely to banish from her current accounts, her old original *non-decimal* sou. Moreover, so very slight a change as about two grains in seventy (3 per cent. only) in the amount of silver at present employed in the coin representing the 24th of the pound sterling, or *tenpence*, and our other silver coinage, or in the present French *franc*, in the double franc or *florin*, and in the quintuple franc or *dollar*, both which wide-spread decimal systems are corresponding modifications of the French, would render the silver coinages of all these leading decimal systems of the civilized world *identical*, and therefore international and interchangeable; and all these principal forms of account at once strictly and mutually so far corresponding, whatever the standard of value and legal tender each might for a time choose to retain†.

Having in 'An Examination of the Report and Evidence of the Committee of the House of Commons, with reference to a simpler, sounder, and more comprehensive mode of proceeding' (published in 1853, 2nd and 3rd editions, with preface and postscript, 1854), in 'A Comparative Statement of the Different Plans proposed of Decimal Accounts and Coinage' (published last year), and in a short 'Appeal to the House,' in the present, already brought under consideration as fully as in his power, the various advantages and important results of this simple operation, and the insurmountable difficulties and objections in the way of every other possible course of proceeding, the author now only observes generally of all these other schemes, that, without one single exception, they each and all necessarily involve such extensive and serious changes in our moneys, both of account and circulation, as must of themselves render simply and absolutely *impracticable*, proposals for reforms,—in the accomplishment of which, all experience has demonstrated that it is especially and essentially necessary, "*stare super antiquas vias*‡."

The author is fully convinced that the practical business habits, and steady common sense of the people, render it unwise and unreasonable to attempt, and altogether impracticable even if attempted, to compel them to submit, thus without any good and sufficient reason, to such extensive and wanton interference with their

* Non-decimal *coins*, it is scarcely necessary to observe, circulate without any inconvenience, *and ever must, with every decimal system of accounts* that exists.

† The grains of pure silver *at present* employed in these four great coinages, where chiefly in use, only differ in amount to the following extent:—

	Grains of fine Silver.
The *English tenpence* contains	67·27
The *French franc* contains	69·43
The *United States*, &c. *dollar*, or five-franc piece, five times	69·11
The *Dutch*, &c. *florin*, or double-franc piece, twice	72·88

As our existing coin was worn out, accurately coincident silver coins of 10*d.* (the franc), 20*d.* (the florin), 30*d.* (the half-crown), and 50*d.* (the dollar), with a silver 5*d.* and copper cent (or 10th of a penny) coins—in addition to the 1*d.*,—would in all probability be permanently adopted. The *vast advantages* of decimals of the 1*d.*, as contrasted with the mil, to *commerce*, and their *necessity to the poor*, have been ably and unanswerably demonstrated by the late Mr. Laurie, far the best informed witness, practically and scientifically acquainted with figures and with business, examined in support of the pound and mil scheme; which plan, however, he publicly and at once renounced on receipt of the author's pamphlet and careful examination of the scheme proposed therein.

‡ Motto of the author's first pamphlet.

well-known long-established moneys, both of account and circulation. That they never will consent and never can be made to consent, to having either their pence or their pounds interfered with, and superseded as has been proposed—in order to introduce, at vast expense and inconvenience, a troublesome, complicated, imperfectly decimal, and utterly isolating system, both of accounts and coinage—when *the most useful, comprehensive, and perfect* of all *possible decimal systems* can, at any moment, be introduced and rendered general, *without losing any one* of the *useful desirable objects and applications of either the pound, the penny,* or *any other existing coin,* without expense, and without the transition being embarrassed by more than a scarcely perceptible amount of change.

On the Progressive Rates of Mortality, as occurring in all ages; and on certain Deviations. By JOHN REID, *Surgeon, Glasgow.*

An individual living to the age of 100 years, would live over the whole breathing-time represented in the accompanying Table; which shows columns numbering 100 years from left to right, and a scale marking the same from top to bottom. According to both ancient and modern computation, there are three *generations* in every 100 years, *i.e.* the whole population is renewed every $33\frac{1}{3}$ years; but the length of a generation varies in different kinds of population. It ought to be longer amongst the better living classes than amongst the poor and improvident, also in some families than in others, the individuals of some families being longer lived than those of others. In England and Wales the mean duration of life, which measures the length of a generation, is about $35\frac{1}{2}$ years, but it is generally reckoned at about 33 only, which is the *probability, expectancy* or *value* of life at birth. From this point we start in estimating the value of life either at the particular ages, or throughout the different periods; such estimation being generally made on a given number of lives, the ages of the different individuals having been ascertained as correctly as possible at their deaths. Such having been ascertained, say of 10,000, the number dying at the different ages, or betwixt every five years, will represent the proportional mortality or the per-centage of deaths; so upon finding that of 10,000, we infer it to be a fair criterion in estimating the per-centage over a whole population. In the Table the value of life at birth is shown to be 33 years on the scale, *i.e.* taking off 67 years from the 100; now, during the first five years, of 10,000 born, 3900 die, or $36\frac{3}{4}$ per cent.; during the next, or second five years, only 460 die, or $4\frac{1}{2}$ per cent. A child having lived five years has passed through the most dangerous period; its probability of life is therefore greater than it was at birth, and is represented in the Table at 48 years, which was long considered the maximum value of life according to the average of life tables. But the average of the Registrar-General's Reports shows the greatest probability to be at the age of nine, so in adopting this still greater decline, the value of life at that age is 54 years, which is perhaps rather too high; but we have a still higher probability on the Table, viz. 58 years, which is shown at the age of 13.

Starting from either of these epochs, we find certain rates of mortality occurring in the different periods of life, deduced from the deaths at the different ages. As the average of the Registrar-General's Reports must be nearest the truth, we will take the age of nine as representing the greatest probability of life, that almost gradually decreasing with advancing age. The figures above the diagonal line on the Table, show the probability of life at the different ages; *e. g.* at the age of twenty-five, it is 42 years; at fifty, 25; at sixty-five, 15; at eighty, 5; and at a hundred, $1\frac{1}{4}$ year. And it may be observed that at the age of thirty-seven it is 33 years, being the same as at birth.

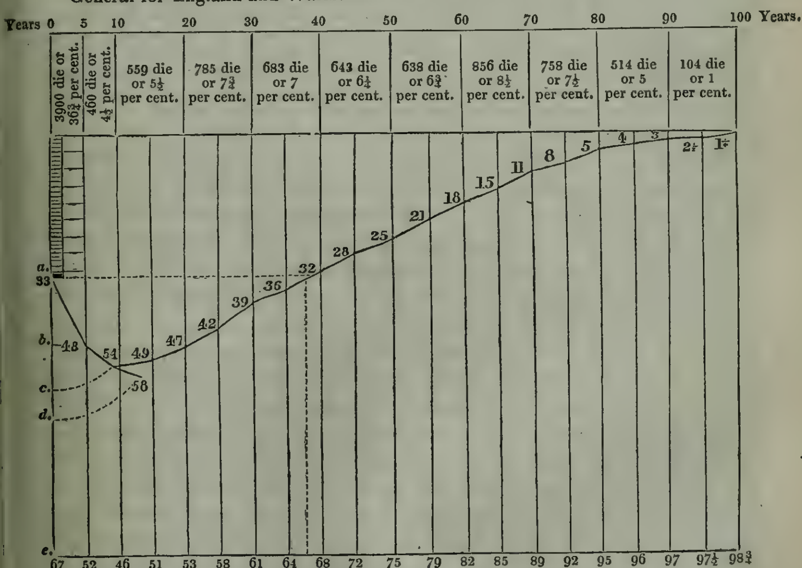
It is somewhat surprising how little deviation there is in the different periods of life, excepting infancy and early childhood, and extreme old age. The ascent, from the age of nine to death, is but a slightly deviating rise to the extreme age of eighty, showing the natural inherent powers in man to pass the threescore years and ten; and if his bodily functions were not deranged in the course of life from many different exciting causes, death in the intervening periods would be an exception only to that in old age, occurring from the gradual tear and wear of structural parts.

Dr. Buchanan's table shows the number of deaths in the living at the different

ages; *e.g.* out of 100 *born* 14·631 die the first year, and of 100 living at the age of a hundred and six, the whole die in one year. But any *"physiological"* law of mortality based upon the fact of these specified numbers dying in 100 at those ages, only shows the actual mortality of these particular hundreds at the given ages; at the age of one year we may have 14·631 deaths out of the small number of 100 born, but it requires 10,000 to be born to give 100 deaths at the age of 106 years. Consequently such a mode of estimating the law of mortality is entirely fallacious, because the small chance of surviving to the extreme age of 106 years is as 100 is to 10,000.

There is no general law of mortality affecting the different periods of life which can be applied to the whole population of any country, for we find that the rate at the different ages varies according to the circumstances affecting individuals in all ages. In towns the rate of mortality in infancy and childhood is much greater than in the country; and such is the case also amongst the poorer classes, compared with those in comfortable conditions of life. From this fact alone we must trace the causes of the excess of death in infancy and childhood to those physical and moral agencies which derange the functions of the body, and thus affect its physiological or organic actions. But there is no "physiological law" *per se*, which operates in cutting off one individual in infancy and another in old age; if such were the case it would imply *inherent organic imperfection.* Now unless in organic disease superinduced in organic structure, from excited functional derangement, we have no proof that any organ of the body becomes suddenly deranged in its functions without some exciting cause.

Table showing the proportion of deaths in 10,000, at the different periods of life, according to the average of the Mortality Tables, and the Reports of the Registrar-General for England and Wales.



a. Probability of life at birth, and at the age of 37 the same, viz. 33 years.
b. According to the average of life tables at 5 years.
c. According to the Registrar-General's Reports at 9 years.
d. According to other calculations at 13 years.
e. The numbers of years to be deducted from 100 in estimating the value of life at the different periods.

Statistics of Newspapers of Various Countries. By P. L. Simmonds.

In June 1841 Mr. Simmonds read a paper before the Statistical Society, in which he entered into some elaborate details on the statistics of the newspaper press, home and foreign, brought down to the year 1840, which was published in that Society's Quarterly Journal, vol. iv. p. 111. This paper was a continuation of the statistics and details brought down to the present time.

As an illustration of the expansion of the newspaper trade, Mr. Simmonds mentioned that in 1841 there were 505 newspapers in Great Britain, and in 1851 there were 1091. In 1801, 16,000,000 newspaper stamps were issued; in 1811, 24,500,000; in 1821, 25,000,000; in 1831, 33,500,000; in 1841, 60,750,000; in 1851, nearly 90,000,000. In the present year (1855), so far as the returns go, they show at the rate of above 100,000,000, more than 50,000,000 being issued for the first half of the year. The *Times* had made still greater progress in proportion, having a circulation of 3,500,000 in 1837; and, in 1855, at the rate, for the first six months, of 9,000,000 in the year. The number of newspapers in Scotland in 1841, was 70; and the number of stamps taken by them was 4,500,000. In 1851, the number had increased to 117, using 7,000,000 of stamps. In the year 1855, there were 151 newspapers, using 4,500,000 stamps, or at the rate of more than 9,000,000 in the year.

On the Growth and Commercial Progress of the two Pacific States of California and Australia. By P. L. Simmonds.

The startling discovery of the vast metallic and mineral wealth of California attracted to her shores in the space of twelve months, in 1849, more than 100,000 people, 80,000 of whom were Americans; and an extensive commerce has since sprung up at San Francisco with China, the ports of Mexico on the Pacific, Chile, the islands in the Pacific, and Australia. California became, as if by magic, a State of great wealth and commercial importance. It was at first thought that the tide of emigration would keep up at the large ratio of 100,000 per annum; but this has not proved to be the case, for the State progresses much slower now in population —the departures almost equalling the arrivals—and the annual increase by immigration scarcely exceeding 30,000. The population might indeed have been very largely swelled by the Chinese immigrants, who arrived in considerable numbers; but their reception was strongly opposed, and they have been much ill-treated; there seems also no probability of the prejudice against them being removed. In June 1847, the 'California Star,' the first newspaper published in the district, returned the population of the village of San Francisco at 459 souls, 321 males and 138 females; of these 375 were white, and the rest Indians and negroes. Now the city has covered the sandbank, mounted the hills, overflowed into the valleys beyond, encroached upon the waters, and promises ere long, at its ratio of increase, to cover the peninsula between the ocean and the bay.

The population of the State of California on the 31st of December 1853 was estimated at 328,000 souls, composed as follows:—American, 215,000; German, 25,000; of Spanish blood, 20,000; Chinese, 15,000; miscellaneous foreign, 5000; Indians, 20,000; and negroes 2500. Of these, about 65,000 were women, and perhaps 30,000 children. The population of the city of San Francisco is now about 60,000. The number of vessels which entered the port in 1853, coasters and foreign, was 1028, measuring 558,755 tons; and the clearances were 1653 ships, of 640,075 tons. The value of the goods imported is given at £7,000,000, or £20 per head of the population. The exports of gold, however, amounted to £12,000,000, or £34 per head, exclusive of quicksilver and other produce. The tonnage (steam and sail) owned in San Francisco amounted to 63,423 tons, and in other ports of the State steamers amount to 23,566 tons. The freights paid at the port of San Francisco for the year 1853 amounted to £351,000, and the custom duties to £516,200. The arrivals of passengers by sea in the past three years have been as follows:—in 1852, 35,185; in 1853, 15,359; and in 1854, 47,730. In 1852, 990 ships of 444,515 tons entered the port; in 1853, 926 ships of 260,956 tons; and in 1854, 617 ships of 407,485 tons. 571 ships of 353,698 tons cleared

out from San Francisco in the year 1854. A large portion of the passenger traffic is carried on by steamers from the Isthmus. The total number of passengers who crossed the Isthmus of Panama in 1853 was 32,111, and 30,108 in 1854; while this year, owing to the railroad being completed, 40,000 are expected. According to the returns for the present year (1855), each steamer to California takes about 506 passengers, and each steamer returning brings on an average 372. The total increase to the population of California by land and by sea in 1854 was estimated at 50,000. While the average passage by sailing-vessels round Cape Horn from New York to San Francisco is 108 days, by way of Panama the passage is made in less than half that time. Previous to the immigration of the last few years, the population of Oregon did not exceed 1000 inhabitants, exclusive of the Hudson's Bay Company's employees; at present it may be estimated at least at 20,000. Some twenty or more saw-mills and several flour-mills are now actively employed in preparing timber and meal for home use and exportation. The trade with San Francisco keeps twenty vessels of about 4000 tons fully occupied, and there is a semi-monthly line of mail steamers running. There are now twenty-nine river steamers plying to and from San Francisco and the upper towns of the State. At the period of the discovery of gold in California, there were in the United States coin and specie to the value of £20,000,000; in 1854, the amount of specie in the banks and in circulation amounted to nearly £50,000,000, notwithstanding a heavy drain of specie to Europe, amounting in the last four years to upwards of £27,500,000. Messrs. Hussey, Bond, and Hale, a leading mercantile firm at San Francisco, made some elaborate calculations of the gold produce of California up to 1853, which resulted in a total of 57,700,000 dollars.

The result of the various estimates gives fully £70,000,000 sterling as the total yield of gold from California to June 1855.

Crossing the Pacific, let us next observe what gold has done for Australia. The population of Port Phillip in 1846 was but 32,879 souls, of whom 20,184 were males and 12,695 females. There were about 5300 houses in the district. The value of the imports in 1847 was £437,696, of the exports £668,511, of which £565,805 was for wool, and the remainder for horses, horned cattle, tallow, and beef and pork. The revenue then was but £138,219, and the expenditure limited to £63,882. The years 1851 and 1853 may be taken as fair averages of the effect of the gold discoveries on the pastoral interests of these colonies, and the imports of wool into the United Kingdom in those years from Australia were respectively as follows:—41,810,117 lbs. in 1851, and 47,075,363 in 1853.

The imports and exports of Melbourne are only exceeded in value by the two great ports of England—Liverpool and London; and, excepting these ports and Bristol, its custom duties are superior to any other British port. The whole tonnage inwards and outwards in the Thames, in 1850, was 3,289,000 tons, in the Mersey, 3,536,337; into Port Phillip, in 1853, it amounted to 1,204,971 tons. These facts strikingly demonstrate the commercial importance and natural capabilities of the Bay of Port Phillip, as well as that of the colony of Victoria. To summarize the progress of the colony, we may state that the value of the imports into Port Phillip has risen from £744,925 in 1850, to £17,720,307 in 1854; that of the exports from £110,000 in 1850 to 11,775,204 in 1854; the population from 75,000 to about 280,000; and the revenue from £261,321 to £3,015,683 in the same period. The estimated population at the various gold fields of Victoria on the 19th August, 1854, was given at 111,735, of whom 77,500 were men, 16,555 women, and 17,630 children. About one-third of the population are therefore employed in the search for gold. The gold produce of Victoria in 1855 being, in round numbers, two millions and three quarters of ounces, would give to each of these 77,500 men at the diggings about £113 per annum as their average earning, an amount which could never serve for ordinary living, exclusive of the women and children to be supported. Of course many obtained large sums, but the average was of consequence less. Let us now examine what has been the result of the gold mining operations in the colony. In calculating the value of Australian gold I have estimated all as worth £4 per ounce for simplicity of calculation, but the New South Wales gold dust will not fetch this price. The following gives the value of the produce of the gold fields of Victoria, up to June 1855, showing the ascertained quantity, and estimating

the unrecorded produce: ascertained, £33,120,224; unrecorded, £16,223,116—total, £44,143,384. The population of New South Wales in 1846, exclusive of the Port Phillip district (now the colony of Victoria, which then had but 50,475 souls), was 154,534 souls, of whom 92,389 were males and 62,145 females. There were then 26,563 houses in the colony. The revenue was £396,259, the imports to the value of £1,544,327, and the exports £1,187,423. The tonnage entered inwards was 154,904. On the 31st of December, 1853, the population was found to be 231,088; the number of females was 99,720. The number of horses then was 139,765, of horned cattle 1,552,285, pigs 71,395, and sheep 7,929,708—making a general total of live stock of 9,693,153 head, or in the proportion of one horse to every two persons, and seven head of cattle and nearly thirty-four sheep, besides pigs, to each person. The value of the exports of New South Wales reached, in 1853, to £4,523,346; while that of the imports amounted to £6,342,397, or in the proportion of £18 of exports and £26 of imports to each soul of the population. In 1850, the year before the gold discoveries, the value of the exports was but £1,300,000, and in 1853 it was £4,500,000. In 1852 and 1853 the value of the export of gold from New South Wales was respectively £2,600,000 and £3,600,000. The census of New South Wales, taken March 1, 1851, just before the gold discovery at Ophir by Mr. Hargreaves, gave the population at 197,168. It has since increased to about 232,000. We find, then, that while the value of the imports into New South Wales in 1851 was but £1,568,913, it had risen in 1853 to £6,342,757. Taking the transactions of the last four years, the balance of trade has, however, been against the colony by nearly two millions,—the total imports having been £16,578,570, and the total exports £14,633,922. In 1854 the banks doing business in the colony held a stock of coin and bullion exceeding £2,500,000, deposits of about £5,000,000, and a paid-up capital of £3,000,000, and had divided profits ranging from 8 up to 40 per cent. per annum. The exports of colonial produce from Sydney in 1853 were valued at £2,342,362, exclusive of gold. The export of wool was 15,701,465 lbs., against 11,086,974 lbs. in 1852. The pastoral interest seems, therefore, to have recovered from its prostration, for the shipments last year approximate to the exports of 1851, which were 15,268,473 lbs. The value of the imports to Sydney were about £3,000,000. The exports of Sydney and Melbourne together are over 20 millions sterling, and their imports nearly as much. The gold diggings of New South Wales, although less prolific than those of Victoria, according to a careful comparison which I have made, returned nearly £170 as the year's earnings for each digger in 1853. The entire colonial trade of Australia is now very considerable, and a fine fleet of steamers is employed in communicating between the ports of Adelaide, Melbourne, and Geelong, Launceston and Hobart Town, Port Jackson, and the New Zealand settlements. In 1853 the vessels which entered at Sydney from colonial ports numbered 582, measuring in the aggregate 127,074 tons. The entries of other vessels, exclusive of coasters in the same year, were 980, of 316,879 tons—being an increase over 1852 of 259 ships and 118,133 tons. Mr. Simmonds then went at some length into the statistical progress of the other Australian Colonies, Southern and Western Australia, Van Diemen's Land, and the New Zealand settlements, to show the beneficial influence exercised on their interests, commercial and agricultural, by the gold discoveries, which we pass over.

If we look at the effects of the gold discoveries in directing the tide of emigration, we find how much the current has altered, and how strongly it has set southwards within the last three years. In 1851, but 21,532 souls left the United Kingdom for the Australian colonies and New Zealand. Observe, however, the change since the gold discoveries. In 1852, 87,881 emigrants left; in 1853, 61,401; and in 1854, 83,237. From the port of Liverpool alone, 91 ships of 88,418 tons have left already for Australia this year (1855), taking 16,297 passengers. In four years a population has been added to the Australian colonies equal to the whole number of settlers in Australia ten years ago, the emigration of one year being larger than the existing population of Victoria in 1850. According to the census of 1854, the entire population of Victoria is 250,000; so that, in the period of thirteen years since 1841, Melbourne has increased in population elevenfold, and Geelong forty-fourfold. In the three years ending with 1853, we shipped to the Australian colonies produce and manu-

factures from the United Kingdom of the declared value of £21,536,093, which, with the emigration, gave employment to 2041 ships outward, measuring in the aggregate 1,034,459 tons. But the Australian colonists have also been excellent customers to several of the colonial possessions—to Ceylon for coffee, to India for rice, &c., to Mauritius for sugar, to the Straits settlements for spices and Eastern produce. Last year the declared value of our exports to Australia was just upon £12,000,000, or nearly one-eighth of the total exports of the kingdom.

Within the last seven years a population of about 330,000 has settled in California. The result of their labours has been a gold produce of about £71,200,000. In the last four years an addition has been made to the population of Victoria and New South Wales of about 250,000, and the gold they have obtained has amounted to about £51,662,794.

Return of the Number of Civil Actions and Civil and Criminal Prosecutions and Informations in the Circuit for the Northern District of the Island of Newfoundland, from January 1826 *to January* 1855, *being a period of* 29 *years. By* JOHN STARK, *Registrar of the Northern Circuit Court of Newfoundland.*

Duration of term, 2543 days (seven years nearly). Number of days on which the Court sat, 1345 (three years and eight months nearly). Number of writs sued out, 6049. Amount sued for, £193,301. Number of actions tried, 3814. Amount of judgments, £85,972. Number of appeals, 8. Number of executions, 2081. Amount of executions, £35,761. Number of persons criminally indicted, 552. Number of criminal trials, 249. Number of deeds registered in the circuit for the Northern District of Newfoundland, 3307. Value of the property passing under the said deeds, £415,239.

On Moral Training for large Towns. By DAVID STOW, *Honorary Secretary to the Glasgow Normal Training Seminary, Author of the Training System, &c.*

The system of moral training for towns (in conjunction with the ordinary branches of education) was established in this city in the years 1826–27, expressly as an antidote to the exposed condition of youth in such large cities as Glasgow. It is equally suited, however, for rural districts.

During some of the earlier years of its existence, the Model and Normal School for training teachers and children was fixed in the Saltmarket to try its effects upon the children of the sunken masses of that neighbourhood, and in Bridgegate, Wynds, Goosedubs, &c.; and it is highly gratifying to know that during seven years between 1830 to 1838, out of the many hundreds of children, both boys and girls, and who have since grown up to be men and women, only two are known to have been accused of crime or brought before a magistrate. The subsequent conduct of the pupils generally in after life has been of a high moral and intellectual character, and each successive set of pupils since that period present the same results.

About twelve or fifteen years ago the system was introduced into one of the two convict prisons at Parkhurst, Isle of Wight, by persons trained in our normal seminary, and who were ordered by government. After five years' training, so great was the reformation, that out of 206 prisoners, no fewer than 60 received Her Majesty's free pardon, 21 of whom were returned to their friends at home, the remainder being permitted to go free to Australia.

Regarding the children attending the model schools of the Normal Training Seminary, parents uniformly and spontaneously testify to the improved moral conduct of their children at home and among their companions, as well as to the intellectual culture which they receive, and to the benefit which accrues to their health from the exercises both of the playground and schoolroom.

So much are these schools appreciated, that they never have been able to accommodate one-half of the children who apply for admission. At present, and for many years past, about 900 children regularly attend the five model or practising schools of the Normal Seminary, both sexes being in the same classes in the gallery

and in the playground, as a part of moral as well as intellectual training, and with decidedly favourable results.

One of the objects of this training institution was to afford means of professional training to those who were devoting themselves to teaching. Since the commencement of its operations in this respect, twenty-seven years ago, about 2600 teachers, male and female, have been trained to conduct the system. Of these, about 200 have gone to Poor Law Unions in England, and the remainder are scattered over the United Kingdom and the Colonies. At present the number of male and female normal students is 98. The great demand for school trainers from England, may be dated from the year 1837, during which year we were honoured by a visit from Sir J. P. K. Shuttleworth and C. J. Tuffnell, Esq.

The following institutions have been established on the same principle and for the same objects, viz. the Wesleyan Normal College, Westminster (all the masters of which were trained in Glasgow); Church of England Normal College, Cheltenham; Whiteland's Training Institution, Chelsea; Congregational Normal College, Homerton; and in the Colonies, one has been established in Antigua, Jamaica, Calcutta, Ceylon, and Prince Edward Island. In the Danish islands, by order of the Government, the Training System is being universally established under trained teachers from Antigua.

During the seven or eight years previous to the establishment of their own Normal Training College in Westminster, the Wesleyan Education Committee of London sent 442 teachers to be trained at Glasgow for their own schools in England and the Colonies.

Statistics of a Glasgow Grammar School Class of 115 *Boys. By* Andrew Tennent, *Banker, Glasgow.*

About sixty years ago a class was formed in the Grammar School of Glasgow, consisting of 115 boys, whose average age would be eight to nine years, chiefly sons of the Glasgow merchants, manufacturers, and shopkeepers. There were also among them some of the sons of the professors of the college, and of the clergy of the city, both established and dissenting. A son of the then Lord Provost was also of the number, as well as several of the sons of the then magistrates, besides a few sons of operative weavers, masons, and others. Of these 115 boys who entered school together sixty years ago, 76 are known to be dead; the fate of 13 is uncertain; and 26 are still alive; 24 appear to have died before attaining 30 years of age; 21 between the ages of 30 and 40; 13 between 40 and 50; 5 between 50 and 60; 6 between 60 and 63; 7 between 63 and 68; in all 76 ascertained to be dead; and as the presumption is that the 13 uncertain are also dead, the total deaths up to this date will be 89.

The after professions of the 115 boys appear to have been as follows:—

53 Merchants and manufacturers.
7 Lawyers.
1 Editor.
4 Clerks.
3 Military officers.
3 Clergymen.
3 Sailors.
2 Private gentlemen.
2 Bankers.
1 Professor.
1 Artist.
2 Weavers.
1 Exciseman.
1 Private soldier.
1 Warper.
1 Surgeon.
1 Carter.
1 Bank porter.
27 Uncertain, most of whom died young.

115

The author traced the progress in life of these boys, comparing their occupations with the tendencies manifested at school, and notices the political and social changes during the period.

The scene, however, so far as regards them, is now drawing to a close. Of the 115 who began the world together and fought the battles of life, 26 alone remain, now no longer boys, but aged men approaching the ordinary limits of human life—threescore years and ten; and, in conclusion, it may be remarked, that the history of these 115 boys is, probably, the average history of every other 115 boys similarly circumstanced, and may be useful in moderating all mere worldly aspirations.

On the Progress, Extent and Value of the Coal and Iron Trade of the West of Scotland. *By* John Strang, *LL.D.*

The rapid progress which has of late years characterized some of the now largest cities of Great Britain is mainly due to the mineral wealth which surrounds them, to the existence, in fact, of those vast repositories of fuel or of metals which nature has laid up for the use of man in the bowels of the earth. If one only casts his eye over a geological map of this island, he will find in England, a Birmingham, a Newcastle, a Preston and a Manchester, placed in the midst of extensive coal-fields; and on looking at Scotland, he will at once discover, amid the general thinness of habitation and population, at least one fully-peopled district, in the centre of which stands the no less important manufacturing and commercial city of Glasgow, surrounded on every side by the richest strata of coal, iron, and lime. To the mineral wealth which exists in this portion of Scotland may be mainly attributed the prominent position which this western metropolis has lately taken in the commerce and manufactures of the world, and which the following statistical facts connected with the progress, extent, and value of the coal and iron trades of the west of Scotland, of which that city is the central mart, may perhaps in some degree better illustrate.

Although coals have, from a pretty remote period, been wrought around Glasgow chiefly for domestic use, yet it has only been since the introduction of the steam-engine, and still more since the discovery of the economical mode of smelting iron by the hot-blast, that the vast and closely-packed mineral wealth of its neighbouring districts has been at all fully developed and turned to great profit. Even so late as in the year 1831, the quantity of coals brought to Glasgow was only about 560,000 tons, and of that quantity 120,000 were exported, thereby leaving 440,000 tons for domestic uses, steam-boats, public works and factories in the city and suburbs; while the quantity consumed, as well as the ironstone smelted in the comparatively few furnaces then in blast, were small and unimportant. The contrast, indeed, of the state of the coal and iron trades only five and twenty years ago with that of the present moment, is most striking. From the returns obtained through Mr. Williams, the Inspector of Mines for Scotland, it appears that while in 1854 there were 367 collieries in Scotland, 237 of these belong to the west country, 141 being in Lanarkshire, 78 in Ayrshire, 11 in Dunbarton, and 7 in Renfrew. It also appears that during the same year there were 7,448,000 tons of coals raised in Scotland, and of these about 6,448,000 were drawn from pits situated in the four western counties above alluded to. Taking into account all kinds of coals raised, such as splint, soft, and gas, the average price may be fairly estimated at 7*s*. 6*d*. per ton, which shows the produce derived from the coal-mines of the west of Scotland in 1854, to have been about £2,418,000 sterling.

Of the coals so produced,—

2,152,800	tons were consumed in the	manufacture of pig iron.
367,200	,, ,,	conversion of pig into malleable.

Making in all 2,520,000 tons used in connexion with the manufacture of iron; while 926,221 tons were shipped, and 148,312 tons were sent beyond the boundaries northward and southward, per railways, leaving for the manufacturing consumption, steam-boats, and domestic uses of Glasgow, 2,853,427 tons. During the same period the number of persons employed in the collieries, producing this quantity of fuel, were as follows:—

In Lanarkshire	15,580
Ayrshire	6,061
Renfrewshire	790
Dunbartonshire	549
In all	22,980

If the great development of the coal trade, as we have seen, has been of recent origin, the manufacture of iron in Scotland is still more modern, having obtained its present almost marvellous position during the course of the last few years. So late as in 1830, there were only 16 blast furnaces in the West of Scotland, and the whole produce scarcely reached 40,000 tons. It appears, however, that during the year

1854, of the 118 furnaces for the smelting of iron ore, then in full blast in Scotland, and producing 796,640 tons of pig iron, 102 were situated in the two western counties of Lanark and Ayr, 72 being in the former and 30 in the latter, and the produce of these amounted to 717,600 tons. Taking the average price, during that twelvemonth, as 79*s.* 8*d.* per ton, the gross value of this industry is shown to have been £2,858,440. Of this very large quantity of pig iron produced in the West of Scotland, 122,684 tons were shipped direct to foreign countries, and 294,194 tons were sent coastwise from the Clyde, Port Dundas, and the western ports of the Clyde estuary, while 22,865 were sent away by railways; and 171,360 were converted into malleable iron; leaving the remaining 106,497 tons for foundry and other purposes of the district. The number of men employed in iron mining in the district, during 1854, were 3645 in Lanarkshire, and 1943 in Ayrshire, making in all 5588, whose wages, at 22*s.* per week, show an annual expenditure on wages of £319,633 12*s.*, while the number of men employed in managing and working the furnaces amounted to 1344, who were paid on an average 4*s.* 6*d.* per day, or an annual aggregate sum of £110,376.

But if the manufacture of pig iron be a modern industry in the West of Scotland, assuredly that of malleable iron is still more recent; for, with the exception of a small work at Wilsontown, which was unsuccessfully attempted there at a somewhat remote period, almost nothing was done in this manufacture till 1839; and even so late as in 1842, the production did not exceed 35,000 tons. During the year 1854, however, the manufacture of malleable iron reached 122,400 tons; and, taking the average price of all sorts, including plates for shipbuilding, to have then been £10 per ton, the gross amount of this industry was £1,224,000. The number of men employed in this branch were about 4000, and the rate of wages paid was 28*s.* per week, showing an annual aggregate amount paid in wages to have been £291,200.

Assuming, then, all these statements to be as correct as perhaps they can possibly be made, let us now see what was the real value, to the West of Scotland, of the whole of these industries in 1854.

Value of coal			£2,418,000
Value of pig iron		£2,858,440	
Deduct value of coal used in smelting, say 3 tons of coal for each ton of pig, or 2,152,000 tons at 7*s.* 6*d.*		807,300	
			2,051,140
Value of malleable iron		£1,224,000	
Deduct value of pig iron used, say 171,360 tons at 79*s.* 8*d.*	£682,584		
Deduct value of coals used in conversion from pig into malleable, say 367,200 tons at 7*s.* 6*d.*	137,700		
		820,284	
			403,716
Net value of coal and iron			£4,872,856

We find also from the foregoing statements that the number of persons employed in these industries, and the wages paid, were as follows:—

Employed in collieries	22,980	at 21*s.* per week	=	£1,254,708
„ iron mining	5,588	22*s.* „	=	319,633
„ attending furnaces	1,344	4*s.* 6*d.* per day	=	110,376
„ malleable iron works	4,000	28*s.* per week	=	291,200
	33,912			£1,975,917

In short, the foregoing tables show that the coal and iron works of the West of Scotland, of which Glasgow is the great central mart, produced no less a sum to those connected with these establishments than £4,872,856, and gave employ-

ment to 33,912 persons, who received for their labour wages to the amount of £1,975,917.

When the magnitude of these figures, and the value which they bear on the social and economical condition of this great mining and manufacturing district, are calmly considered, it will not be difficult to arrive at one of the main sources of the lately greatly increased wealth of Glasgow and its vicinity, or to account for one of the chief causes of attraction to the industrious mechanics and labourers from all parts of the country, which have already rendered the united counties of Lanark, Ayr, Renfrew, and Dunbarton, one of the most thickly peopled and well-conditioned portions of Great Britain.

The Effect of the War, in Russia and England, upon the principal articles of Russian produce. By Richard Valpy.

This paper is limited to the consideration of the articles commonly known as Baltic produce, in which the two countries have traded principally with each other. These articles are few in number, and comprise tallow, flax, hemp, linseed, and bristles. In ordinary times the chief proportion of the total exports are sent to England. It also happens that the principal articles which we are in the habit of importing from the Baltic ports of Russia, constitute our chief supply of such articles.

The following Table shows the relative importance of England and Russia to each other, in the demand and supply of these articles :—

Articles.	Annual average 3 years, 1850–52.	
	Proportion of total exports from Russia sent to England.	Proportion of total imports into England, received from Russia.
Tallow ...	77 per cent.	64 per cent.
Flax	64 ,,	67 ,,
Hemp......	56 ,,	53 ,,
Linseed ...	60 ,,	68 ,,
Bristles ...	63 ,,	81 ,,

On the average, therefore, of the three years 1850–52, the large proportion of from one-half to three-fourths of the total of such exports from Russia went to England, and of the total of such imports into England the like proportion came from Russia.

In 1853, under the influence of political events, there was a large increase of our imports of Russian produce, especially from Russia itself; but in 1854, whilst our total imports of such articles, with the exception of tallow and bristles, were well maintained, our supplies from Russia materially diminished.

In 1853, the increase of our total imports of the articles above alluded to over the average of 1850–52 ranged from 0½ to 49 per cent., and of our imports from Russia from 12 to 65 per cent. In 1854 our total imports of tallow, bristles, and flax decreased 36, 16 and 12 per cent. respectively, whilst hemp and linseed were increased by 6 and 22 per cent. But upon all these articles imported from Russia in 1854 there was a decrease of from 13 to 54 per cent. As far, therefore, as the Russian trade with England is concerned, the blockade of the Baltic ports in 1854 may be said to have stopped one-half of the usual Russian exports; although in 1853 Russia sent to England considerably more produce, the total exports of produce to all countries were not correspondingly increased.

The next Table shows the total imports into the United Kingdom, and the imports from Russia, on the triennial average, and in each of the years 1853 and 1854.

Articles.	Total Imports into United Kingdom.				
	Average of 1850–52.	1853.	1854.	Increase or Decrease. 1853 over average.	Increase or Decrease. 1854 over average.
Tallow cwts.	1,170,471	1,175,754	749,721	+ 0½ p. cent.	− 36 p. cent.
Flax „	1,473,228	1,883,374	1,303,235	+ 28 „	− 12 „
Hemp „	1,138,778	1,237,872	1,211,297	+ 9 „	+ 6 „
Linseed qrs.	679,619	1,035,335	828,513	+ 34 „	+ 22 „
Bristles cwts.	19,339	28,902	16,141	+ 49 „	− 16 „
	Imports from Russia.				
	Average of 1850–52.	1853.	1854 * (through Prussia).	Increase or Decrease. 1853 over average.	Increase or Decrease. 1854 over average.
Tallow cwts.	753,785	845,962	342,934	+ 12 p. cent.	− 54 p. cent.
Flax „	1,002,655	1,287,993	651,994	+ 28 „	− 35 „
Hemp „	601,362	813,231	386,824	+ 35 „	− 37 „
Linseed qrs.	463,620	765,019	402,694	+ 65 „	− 13 „
Bristles cwts.	15,181	22,123	7,326	+ 46 „	− 52 „

It is more difficult to arrive at any comparative results for the year 1855. Our imports of Russian produce from the Baltic have usually been received almost entirely in the last six months of the year, and the imports in the first six months of past years are too inconsiderable to afford the means of judging of the relative importance in each year. It is probable that the shipment of the articles from the Prussian instead of the Russian ports in 1855, may so alter the time of arrival in this country, as to change considerably the proportions of our imports in the first and second six months of the year. The commercial accounts from Russia report a continued diminution of exports in the present year. There is no doubt that the prices of Russian produce advanced considerably in expectation and upon the outbreak of war. Speculative apprehensions in this country appear to have created a pressing demand for Russian produce, and induced a prevalence of high prices, and a comparatively large import from all countries did not save the consumer from the disadvantages of high prices.

The high prices in 1854, consequent upon the interruption of commercial operations, have not been maintained in 1855; and in July 1855, the prices of tallow, flax, and hemp in Russia are reported as lower than in December 1852.

With reference to the fluctuations in the prices in England of the principal articles of Russian produce for each year, it may be remarked that—

In 1852, the range closely corresponded with the previous 1850 and 1851.

In 1853, tallow and hemp alone experienced any considerable rise. Tallow varied from 44*s*. 3*d*. to 58*s*. 6*d*. against 35*s*. 6*d*. to 47*s*. 3*d*. per cwt. in 1852, and hemp from £35 to £39 10*s*. against £29 10*s*. to £38 10*s*. per ton in 1852. Tallow continued to advance throughout the year, but hemp declined after the first four months.

In 1854, all the articles rose in price, particularly upon the declaration of war in March; and hemp was then very much advanced. In comparison with 1853, the highest price for tallow was 67*s*. 6*d*. against 58*s*. 6*d*.; for flax, £56 against £41; for hemp, £70 against £39 10*s*.; and for linseed, 65*s*. against 48*s*. Tallow and linseed remained high throughout the year, but flax and hemp soon fell, and considerably towards the end of the year.

In 1855 only linseed shows as high a price as in 1854, and it has advanced from 65*s*. to 72*s*. per quarter. Tallow has declined, and having been at 49*s*. 3*d*. or 10*s*. below the lowest of 1854, was 55*s*. in August, or about 10*s*. below the highest in 1854. Hemp is also much lower, having been £56 in January as compared with £70 in April 1854, and in August it was £44 10*s*. Flax is quoted at £40 to £46 in August, against £56 in May 1854.

* After deducting the average imports from Prussia before the war.

In the important articles tallow, hemp, and flax there has been a considerable reduction of price in 1855, in England, in favour of the consumer; and the Russian producer does not appear to have his diminished exports supported by high prices.

Prices in Russia did not rise in 1854 in anything like the same proportion as in England. The prices for 1855 are unfavourable to the Russian producer. With low prices, working expenses increased by the pressure of the war, and an enhanced cost of transport, the producers must be placed in a most unfavourable position.

The cost of transport by land in Russia is still increasing, and as it must continue very high, that alone will prevent the existence of any considerable trade. With a price of £32 10*s*. per ton for tallow at St. Petersburgh, no less than £14 10*s*. in addition is stated to be the cost of carriage to Memel, with £5 more for delivery in London; and the price of tallow in Russia must therefore remain very low to allow it to come to England in competition with supplies from other countries, and also with the important article of palm oil, the import of which has greatly increased, and which can be much used as a substitute for tallow.

That Russia can export by land what she has hitherto sent by sea, is next to impossible. The distances to be traversed, the comparative absence of practicable routes, and the bulk of the articles to be forwarded, would be great impediments even in time of peace, when all the resources of the country were in free operation.

The results of the inquiry attempted in the present paper may be thus stated :—

That, previous to the war, Russia exported her principal productions chiefly to England, and England imported such productions chiefly from Russia.

That, since the outbreak of war, the exports of produce from Russia have diminished to a greater proportionate extent than the general imports of such articles into England.

That there is not an increase in the value of produce in Russia to compensate the producer for the decrease of exports, whilst supplies from other countries than Russia will prevent the consumer in England suffering from very high prices.

That the difficulties and consequent expense of transport by land in Russia render the injuries of the blockade necessarily very severe.

On the Condition of the Labouring Population of Jamaica, as connected with the present state of Landed Property in that District. By RICHARD HUSSEY WALSH, *LL.B., Professor of Political Œconomy in the Dublin University.*

Some years ago there were great complaints from Jamaica that the wages demanded by the enfranchised negro were so exorbitant it was impossible to continue the production of sugar or other articles, without the employers being ruined. Before the blacks were emancipated, it was said much gain could be derived from their labour, stimulated into efficiency by coercion; and even after emancipation, the employer, though cursed with an indolent workman, was allowed some compensation for that disadvantage by the artificially enhanced price of his produce, arising from duties in favour of sugar and other articles raised in the colonies; but these resources being gone, nothing but ruin, it was alleged, remained for Jamaica. But the very interesting work of Mr. Bigelow of New York, entitled "Jamaica in 1850," brought forward some statements showing that insolvent proprietors, not indolent labourers, were at the bottom of the evil,—much in the same way as in Ireland at the time of the great famine. The Council of the Dublin Statistical Society were induced, by the similarity presented by Mr. Bigelow's account of distress in Jamaica, and the contents of their own publications relating to Ireland, to institute an inquiry relating to the former, the result of which furnishes the subject of the present communication. They forwarded a set of queries to some intelligent people in Jamaica concerning the condition of the labourers and the state of landed property. The replies were forwarded in 1853, and since that there has been an opportunity of verifying them by comparison with certain half-yearly returns of the Jamaica stipendiary magistrates, relating to the social state of that country, and made last year by order of the Governor, Sir Henry Barkley. From both it appeared that wages, instead of being excessively high, were wretchedly low, varying from 6*d*. to 1*s*. 3*d*. a day; and the difficulty occasionally experienced of getting labourers was explained by the fact, that their wages, low as they were, were sometimes promised

only, and not paid. This shows the folly of deeming high wages the cause of the existing distress, as well as the worse than folly of attempting to remedy it, as is done to a pretty great extent, by immigration, at the cost of the very labourers whose wages are to be beaten down by the competition of the new-comers, the funds for the purpose being raised by import duties on the articles principally consumed by the lower classes. The true cause of the distress is shown to be the insolvency of the proprietors, which prevents them from turning the land they own to a profitable account; and this state of insolvency was prior to the Emancipation Act, or withdrawal of duties in favour of colonial produce, as appeared by some memorials of the House of Assembly which were cited in the above-mentioned returns, referring to periods intervening between 1772 and 1811, as well as from various other sources. The evil had been growing up steadily for many years under a vicious system, and there must have been a break-up sooner or later. The disturbances resulting from emancipation, and the removal of duties in favour of colonial produce, contributed, it is true, to hasten the crisis; the alarm occasioned by the measures leading creditors to force their debtors to a settlement; but had not this revealed a pre-existing state of insolvency, the inconvenience would have been but temporary. As it is, it cannot be removed until much of the landed property of the island has been sold, and transferred to solvent persons. But it is impossible the Court of Chancery in Jamaica, with all the faults of its original in the parent state, can fulfil this requirement. Its procedure is so slow and expensive, that creditors often fear to set it in motion; and should they muster courage enough, they may find no solvent person willing to purchase, owing to an apprehension of the title given by the Court proving afterwards bad. In the meanwhile the lands get under the management, or rather mismanagement, of Chancery receivers, and so matters proceed from bad to worse. And these defects multiply with tenfold powers according as there is more work to be done. Business gets into interminable arrears—is only begun and continued, but never finished. The remedy for this is plainly the introduction of Encumbered Estates jurisdiction into Jamaica. By a cheap and expeditious process, creditors are encouraged to come forward to realize their demands, and the land is quickly disentangled from the fetters of nominal ownership, should purchasers also come forward. And this they will do, because the title given to what they buy is indefeasible, being parliamentary. Such a measure has already been prepared, and will, it is to be hoped, soon become the law of Jamaica.

The price of Silver of late years does not afford an accurate measure of the value of Gold. By RICHARD HUSSEY WALSH, *LL.B., Professor of Political Œconomy in the Dublin University.*

The supplies of gold of late have risen from about £3,000,000 per annum, their amount in the beginning of the present century, to from £30,000,000 to £40,000,000. Notwithstanding the magnitude of the previous aggregate supply of that metal, gradually accumulated as it had been for many ages, recent increased production has by this time been proceeding long enough to have imparted a very appreciable effect to the entire stock throughout the world, and we are thus led to imagine that some analogous change in value should have manifested itself, and abundance produced its natural result—cheapness. Such is not the general opinion, however. The price of silver, it has been observed, which was 4*s.* 11*d.* per oz. a few years ago, then rose a little, and has remained since on an average at 5*s.* 1*d.* Its supply, unlike that of gold, has been pretty steady for a long time, and has not varied much from £7,000,000 to £8,000,000 per annum within the present century. This steadiness in supply has induced the belief of a corresponding steadiness in value; and as the price of the metal, measured in our currency, of which gold is the standard, has varied so little, as before stated, it is argued that gold also must have remained steady in value, as otherwise it could not have preserved a relation so nearly constant to the worth of the other precious metal. But the mistake here is as regards silver. It is true its supply has remained steady; but the demand has fallen off considerably, and therefore the metal must have declined in value. In countries using a double standard, that is where payments to any amount may be made indifferently in sums of money containing fixed relative quantities of either of the precious metals, the

growing abundance of gold has led to its employment instead of silver. The most remarkable instances of countries where such a system prevails are France and the United States. To give an idea of the extent to which the demand for silver has there fallen off, and that for gold advanced, in 1849, before the late discoveries, the coinage of the former metal for both countries reached the amount of £8,000,000, and that of the latter about £2,000,000; while in 1853 the silver coined was little more than £2,000,000, but the gold above £23,000,000. This new demand for gold, it is true, has contributed to check its decline in value; but, on the other hand, the falling off in the demand for silver must have brought down its value; and so much, therefore, must gold have declined over and above the change manifested by the slight alteration in the price of silver of from 4*s.* 11*d.* per oz. (on an average) to 5*s.* 1*d.* This shows what has become of the recent supplies of gold, a question often asked, besides conveying an important lesson as to its change in value.

In confirmation of the preceding, it is to be remarked that prices generally have been rising of late; and as there seems no way of accounting for the observed fluctuations by reference to causes peculiar to each, they must be partly attributable to a depreciation in the value of our currency; that is, to a depreciation of gold, it being our present standard of value or measure of prices.

Before long, gold will have ended its effect in displacing silver; and its extra market being thus filled up, we may expect a rapid decline in its value. Should such take place, all pecuniary contracts must be deranged by the resulting rise in prices, and impediments to the formation of new ones created. To obviate the mischievous consequences which would thence follow, the standard should be changed from gold to silver; bank notes and other instruments of credit thenceforward entitling the holder to receive a certain specified amount of the latter metal instead of the former, as at present. The only inconvenience this could lead to would be, that in England, where no notes for less than £5 are permitted, it would prove troublesome to carry about one's person so much silver for making payments to any amount under £5 as the change of standard would require. In Scotland and Ireland no such effect is to be apprehended, as there £1 notes can be, and usually are, employed in adjusting all domestic exchanges in which the sovereign exclusively must be used in England. But is there any good reason why £1 notes should not be permitted? There are several arguments to that effect certainly, but not one that appears valid, at least under existing circumstances. The plain and obvious remedy, therefore, for averting impending monetary disturbances is to adopt a silver standard, and allow the use of £1 notes in England as in Scotland and Ireland. And from this might be derived an auxiliary advantage. The issue of £1 notes not having been permitted of late in England, is not the subject of a vested interest in bankers, as is the case with notes of larger amount. Hence on the same principle that under Peel's Act of 1844, £22,000,000 of notes unrepresented by bullion are allowed to enrich the banking community, whatever amount of £1 notes might safely be left unrepresented could justly be appropriated for the benefit of the public and relief of the tax-payer.

On our National Strength, as tested by the Numbers, the Ages, and the Industrial Qualifications of the People. By JOHN YEATS, *F.R.G.S.*

Great Britain has a relative as well as an absolute existence. It may be regarded as one of the industrial communities of the world—as the heart of the British empire, or as the home of the Anglo-Saxon people; but in each of these points of view it is becoming, *territorially*, of less and less importance.

The soil and natural resources of surrounding states are improving, while the superiority we once enjoyed, in the possession of raw material, has been sensibly impaired, by the increased facilities afforded, by steam navigation, for intercourse between the most distant parts. Unless the waves of the Atlantic subside, our littoral frontiers cannot be enlarged, but the colonists who have left our shores are spreading in every direction, and Anglicising so much of the globe, that we may safely assert the English language is spoken, and English habits and feelings are predominant, over a tract of the earth's surface fifty times as great as this our island home. To maintain our position, we shall have to put forth all the national

strength. It lies chiefly in the numbers, in the youthfulness, and the industrial qualities of the people.

The population of Great Britain in 1651 was computed to be 6,378,000.

In 1751, 7,392,000; equal to 1,014,000 increase in a century.

In 1851, 21,185,000; equal to 13,793,000 increase in a century.

Between 1801 and 1851, the population of Great Britain increased 93·5 per cent.; that of Ireland, however, only 36 per cent.

The increase in the United Kingdom from 1841 to 1851 has been 3 per cent. only, making it less than that of some of the old states of Europe.

There is a view to be taken even less satisfactory than this. Between 1831 and 1841, there was no county in England which exhibited a decrease in numbers. Between 1841 and 1851, twenty-seven counties in England and Wales, and sixty-six districts of those counties, showed sensible diminutions, which extended more or less over the greater part of Ireland, the north of Scotland, the north of Wales, and the west of England.

In England and Wales there are said to be 55,110 square yards to each house, and 10,077 square yards to each individual; in Scotland, 262,024 square yards to each house, and 33,589 square yards to each individual.

The absolute density varies very considerably in different localities, from 18 to the square mile in the district of Bellingham, Northumberland, to 185,751 in the district of East London. From the map of Scotland, we see how thickly the hives of industry are clustered around the Firths of the Clyde and the Forth, and the plains and coal-fields between the Cheviot Hills and the Grampians. In England, the banks of the Mersey, the Severn, the Thames, the Humber, the Tyne, are thronged, and along the centre of the country population passes like a tide.

The tendency of the people to increase in towns, and to remain stationary in point of numbers in the rural districts, is very remarkable, and deserving of especial attention. In the towns, taking them as a whole, there are 5·2 persons to an acre—in the country, 5·3 acres to a person. In the former, there are 3337 persons to a square mile; in the latter, 120 only. The growth of the population throughout the United Kingdom is principally in the manufacturing and maritime, not in the agricultural districts.

There is a close but not inseparable connexion between numbers and strength. The people of Great Britain are neither infirm nor impoverished, yet the effective portion of the population seems at first sight small. Of 21,185,000, the males, at the soldier's age, in 1851, amounted to 3,193,496. Infancy and age, with all the ills that flesh is heir to, affect the national strength.

Great Britain contained, in 1851,—

Under 1 year of age	578,543
15 ,,	7,458,080
20 ,,	9,558,114
Between 20 and 40	6,555,954
40 and 60	3,526,342
60 and 80	1,414,798
80 and 100	129,483
Above 100	319

The Commissioners state in their Report, that there can be now no doubt that some of the twenty-one millions of people in Great Britain have lived a century, "which may therefore be considered the circuit of time in which human life goes through all the phases of its evolution." The probable lifetime of a male at birth is nearly 45 years. The mean lifetime, or the average number of years that males live after birth in England, is rather more than 40 years (40·36 years), so that the majority of us live only about two-fifths of the years others attain to—or, may we not rightly say, two-fifths of our appointed time? Could the full period of existence be survived by all, that prolongation would be tantamount to more than doubling the present population. But while the average duration of life is 45 years in Surrey, it is only 25 in Manchester and Liverpool. It appears, too, that *the population is now younger* than it would be by the natural standard, younger probably in England and Scotland than in any country in Europe.

In our country, of 4,694,583 children of the ages 5 to 15, only 2,405,442, or little more than half the number, are returned by the parents and heads of families as scholars at home or at schools.

The industrial qualifications of the people may be estimated from the list of occupations, and the number of persons severally engaged in them. Without entering into details, Mr. Yeats states his conviction, after careful study, to be, that by far the largest proportion must be regarded as unskilled, and consequently least productive labour; and deplores the immense amount of energy and capacity for culture left wholly unemployed, and thus lost to the community.

We may yearly anticipate more rivalry in the arts, more competition in manufactures. The very year of the census was that of the Exhibition. A second display of the world's industry has just been held in Paris. It was remarked by the juries on the first, that although we bore away the palm in many points, in almost all our supremacy was challenged, in some utterly denied. Superiority which seemed our own by hereditary right was slipping from us. Our long experience had given us unrivalled excellence in a few departments, but wherever the highest requirements of art or science were concerned, those countries took the foremost place in which industrial instruction was the most widely diffused. This point seems to be the weakest in our consideration of the national strength. We want more and better training for the young, which will bring about intelligence, abundance, economy, prolongation of life, and an increase of productive power in the great body of the people.

MECHANICAL SCIENCE.

Opening Remarks on the Objects of the Section. By W. J. Macquorn Rankine, *C.E., F.R.SS. L. & E., President of the Section.*

In opening the proceedings of this Section to the British Association, I will address to you some remarks on its nature and objects.

Although this Section bears the title of "Mechanical Science," it is well understood that questions of *pure* or *abstract mechanics* form no part of its subjects.

The object of this Section is to promote the *advancement of science as applied to practice in the Mechanical Arts.*

The special utility of this Section arises from the fact, that the application of scientific principles to practice is a study of itself, distinct alike from pure science and from pure practice.

On the one hand, the cultivation of mechanics and other branches of natural knowledge, in a manner purely scientific, has for its object, first, to improve the mind of the cultivator intellectually and morally; and secondly, to qualify him, if possible, for assisting in the advancement and diffusion of knowledge; and with this view each subject requires to be treated so as to investigate how the laws of particular phænomena are connected with the general economy of nature and the structure of the universe.

On the other hand, the cultivation of *purely practical knowledge*, such as is acquired by experience in business connected with the mechanical arts, has for its object to enable the cultivator to judge of materials and workmanship, and of questions of convenience and commercial profit, to manage and direct the execution of work, to imitate existing structures and machines which have proved successful, and to follow rules, the utility of which has been established by practice.

The gap between those two kinds of knowledge is so wide, their methods and objects are so different, that rare as it is to find individuals who have cultivated both, and profited by each independently, it is still more rare to find those who are able to combine their advantages; and hence seems to have arisen the prejudice, once deeply rooted and widely spread, but now happily fast disappearing—that theoretical and practical knowledge are mutually inconsistent and exclusive.

In fact, the study of scientific principles with a view to their practical application is a distinct art, requiring methods of its own.

This third and intermediate kind of knowledge, is that for the advancement of which this Section of the British Association was established.

It enables its possessor to plan a structure or machine for a given purpose without the necessity of copying some existing example—to compute the theoretical limit of the strength and stability of a structure, or the efficiency of a machine of a particular kind—to ascertain how far an actual structure or machine fails to attain that limit, and to discover the cause and the remedy of such shortcoming—to determine to what extent, in laying down principles for practical use, it is advantageous, for the sake of simplicity, to deviate from the exactness required by pure science; and to judge how far an existing practical rule is founded on reason, how far on mere custom, and how far on error.

Of those advantages, the more eminent of the designers and constructors of great works of mechanical art are well aware, and have extensively availed themselves; but much still remains to be done towards impressing the general public with a due sense of the mutual dependence and harmony between sound theory and good practice; and towards the attainment of this object, it cannot be doubted that the proceedings of this Section of the British Association have been and will be of important service.

Another benefit, towards which the proceedings of this Section are conducive, arises from the fact, that in many cases the best, and in some cases the only means of impressing on the public mind the truth and the importance of scientific principles, consists in their practical application, which thus re-acts beneficially on the diffusion and the appreciation of theoretic knowledge.

There is also a beneficial reaction of practice upon theory of a different, but a not less important kind; and that is, when the progress of the mechanical arts either suggests problems for scientific investigation, or affords data for their solution, or leads to the improvement of the instruments of scientific experiment.

Fifteen years since, there was established by the Crown, in the University of Glasgow, a Chair of Mechanics, whose history well illustrates the prejudices which formerly prevailed on the subject of the connexion between theory and practice, and the extent to which those prejudices are disappearing. That chair was not established for the teaching of purely theoretical knowledge, which had been already well provided for by the older chairs of the University. It was not for the teaching of purely practical knowledge, which can be acquired by experience in business alone. An impression seems to have at first prevailed, that the chair was of no use; and in consequence, the attendance (notwithstanding the great ability and energy of the Professor, Mr. Lewis Gordon) was at the outset so small that he was induced for some sessions to discontinue his lectures. But, taking into consideration the progress which a due appreciation of the advantages of practically applied science had made of late years, Mr. Gordon resumed his lectures last winter, and obtained at once a numerous attendance of students, who showed, without exception, an earnest zeal to profit by his instructions. That chair bears the same relation to the Chair of Natural Philosophy, which Section G of the British Association bears to Section A.

These general statements of the advantages of that kind of knowledge which it is the business of this Section to advance, will, I trust, be amply illustrated by the proceedings of the present meeting; for I am happy to be able to state, that the papers which will be laid before us are numerous and interesting, and in short, such as might be expected at a place of meeting whose neighbourhood is well known to abound in striking instances of the successful application of mechanical science to practice.

For the discussion of that subject a more appropriate scene could not be found than this University, whose walls afforded shelter, and whose inmates, invaluable friendship, to the early days of obscurity and toil of him who afterwards showed to the world the brightest example of that combination of practice and science which it is our aim to promote—James Watt.

On Railways and their Varieties. *By* W. Bridges Adams.

The object of this paper was to point out the importance, and in some cases the necessity, of adapting a classification and construction of railways, with reference to their peculiar traffic. It was shown, that on railways with frequent trains, it was unsafe to travel at different rates of speed; and that the high speed deemed essential

for express trains was impracticable with goods trains, without rapid destruction to the rails, road, and machinery. That slow trains with many passengers, and goods trains also, were much more important to revenue than express passengers, who were in many cases a positive loss, by interfering with other arrangements. That duplicating the lines of rails, to divide them into goods and passenger lines, would not remedy the evil, as the stations and goods warehouses would require many intersecting crossings, and the expense of alterations, in purchase of land, which has already taken an additional value, widening bridges and tunnels, without producing the desired effect, would cost far more than an altogether new line, which would permit the most rapid traffic possible to circulate over it. It was stated, that the actual loss of direct long passenger traffic in money receipts would be far more than compensated by the increase of goods traffic, and the multiplication of local traffic of various kinds; traffic that could never be competed for by rival lines unless the fares were kept too high. That if such a course were pursued, the existing lines would become commercial streets, thickly peopled by population flocking to their borders.

He proposed the formation of express lines, which could be managed by a very small staff, without the expense of stations, and could run at the rate of fifty or sixty miles an hour. He proposed improved springs, better modes of communication, and larger carriages, with all conveniences of refreshments, &c. He also proposed that an arrangement should be made with the French Government for the extension of the principle, and that a large steamer should be made, to overcome the turbulence of the Channel, and projecting piers at Folkestone. He suggested that lines of rails should be laid on the level part of turnpikes, to be used either with horse or by means of locomotives. The latter might, when not in use, be employed in farm operations.

On Artillery and Projectiles. By W. Bridges Adams.

This paper gave a description of various kinds of projectiles, and the reasons why gun-cotton is better for blasting rocks than for gunnery. The first guns in use in all countries were long; but the inconvenience of very long guns was the cause why the length was curtailed, and why also carronades and mortars were invented. The paper then went on to describe the material of which artillery should be made, and the proper mode of manufacture. An improved trunnion was noticed, with some original suggestions regarding the form of wadding and shot best suited to give sure aim and increased velocity and penetration. In giving his idea of the best form of a ball, Mr. Adams thought that the conical form, with feathers, was the best, which is exactly that which Mr. Kennedy, of Kilmarnock, has lately patented, and which has been experimented upon lately at Ardrossan and Troon. The idea of an elongated ball, which should also be charged like a bomb, has also been anticipated by Mr. Kennedy. Welded guns, united by hydrostatic pressure,—the coating inside with another metal to prevent abrasion,—and several other improvements, which have in part been adopted by inventors, were also recommended.

On Mechanical Notation, as exemplified in the Swedish Calculating Machine of Messrs. Scheütz. *By* Henry P. Babbage.

Mr. Babbage said,—The system of describing machinery, of which I am about to give a brief outline, is not new. It was published by Mr. Babbage in the 'Philosophical Transactions,' in the year 1826, where apparently it did not attract the notice of those most likely to find it practically useful. It had been used for some years before this in the construction, for the Government, of the Difference Engine, which is now in the Museum at King's College, London; and it was also used in the contrivance of the Analytical Engine, on which my father was engaged for many years. Indeed, without the aid of the mechanical notation, it would be beyond the power of the human mind to master and retain the details of the complicated machinery which such an engine necessarily requires. Its importance as a tool for the invention of machinery for any purpose is very great; since we can demonstrate the practicability of any contrivance, and the certainty of all its parts working in unison, before a single part of it is actually made. It is also important both as a means of understanding and of explaining to others existing machinery;

for it is utterly impossible to make the notation of a machine without comprehending its action in every single part. There are also many other uses, which I shall not now stop to mention. The general principles of the notation are the same now as in 1826; but the practical experience of many years has, of course, suggested several alterations of detail, and led to the adoption of some important principles.

To understand the construction of a machine, we must know the size and form of all its parts,—the time of action of each part,—and the action of one part on another throughout the machine. The drawings give the size and form, but they give the action of the parts on each other very imperfectly, and scarcely anything of the time of action. The notation supplies these deficiencies, and gives at a glance the required information. When the drawings of a machine are made, it becomes necessary to assign letters to the different parts. Hitherto, I believe, this has been left much to chance; and each draughtsman has taken the letters of the alphabet, and used them with little or no system. With respect to lettering, the first rules are, that all *framework* shall be represented by *upright* letters. *Moveable pieces* shall be represented by *slanting* letters. Each piece has one or more working points; each of the *working points* must have its own *small* letter, the working points of *framework* having *small printed* letters, and the working points of the *moveable pieces* having *small written* letters.

Thus we have the machinery divided into Framing, indicated by large upright letters, as A, B, C, &c.; Moveable Pieces, indicated by large slanting letters, as A, B, C, &c.; Working points of Framing, indicated by small printed letters, as a, c, e, m, n, &c.; Working points of Moveable Pieces indicated by small written letters, as a, c, e, m, n, &c.

In lettering drawings the axes are to be lettered first. Three alphabets may be used—the Roman, Etruscan, and written, as—

A, *B*, *C*, &c.

A, B, C, &c.

$\mathcal{A}, \mathcal{B}, \mathcal{C}$, &c.

These should be selected as much as possible, so that no two axes which have arms or parts crossing each other should have letters of the same alphabet. Having lettered the axes, all the parts on them, whether loose or absolutely fixed to them, must be lettered with the same alphabet, care being taken that on each axis the parts most remote from the eye shall have letters earlier in the alphabet than those parts which are nearer. It is not necessary that the letters should follow each other continuously, as in the alphabet; for instance, D, L, T, may represent three wheels on the same axis: D must be the most remote, L the next, and T the nearest. The rule is, that on any axis, a part which is more remote from the eye than another, must invariably have a letter which occurs earlier in the alphabet. By these rules very considerable information is conveyed by the lettering on a drawing; but still more to distinguish parts and pieces, an index on the left-hand upper corner is given to each large letter; this is called the "index of identity," and all parts which are absolutely fixed to each other must have the same index of identity; no two parts which touch or interfere with or cross each other, on the drawings, must have the same index of identity. This may generally be done without taking higher numbers than 9. All pieces which are loose round an axis must have a letter of the same character, Roman, Etruscan, or writing; but a different index of identity will at once inform us that it is a separate piece, and not fixed on the axis. For example, ${}^6D$, ${}^6L$, ${}^6T$, would indicate that the three wheels mentioned above were all *fixed* to the same axis; but ${}^6D$, ${}^8L$, ${}^6T$ would at once show that D and T were fixed to the axis, and L *loose* upon it.

I shall now endeavour to explain how the transmission of motion and action of one piece on another is shown. Beginning from the source of motion, each part is written down with its working points; those of its points which are acted on are placed on the left-hand side; those points where it acts on other pieces are placed on the right hand: if there are several small letters, a bracket connects them with their own large letter—

$$\left.\begin{matrix} n \\ \mathrm{o} \end{matrix}\right\} P \left\{\begin{matrix} u \\ a \\ \mathrm{e} \end{matrix}\right.$$

The pieces being arranged, arrow-headed lines join each acting or driving point of one piece with the point of another piece, which it drives or acts on. When a machine is complicated, it is usually necessary to make two or three editions before all the parts can be arranged with simplicity; but, when done, the Trains, as they are called, indicate with the utmost precision the transmission of force or motion through the whole machine, from the first motive power to the final result. It is, however, one of the principles of the notation to give at one view the greatest possible amount of information, provided that no confusion is made; it has been found that, without in any way interfering with the simplicity of the Trains, a variety of information on other points may be conveyed. For instance, whilst looking at the Trains, it is often convenient or necessary to know something of the direction of motion of the piece under consideration, and, by the use of a few signs placed under the large letters, we can convey nearly all that is wanted in this respect. Again, though the drawings of a machine are specially intended to give the size and shape of each piece, yet by the use of some signs of form which are placed above the letters, the form of each piece may be indicated. It is found that these signs do not confuse the Trains; but, on the contrary, extend their use, by making the information they convey more condensed, and more easily accessible.

I now pass on to the Cycles, as they are termed, or to that part of the notation which relates to the time of action of the different parts of a machine. The cycles give the action of every part during the performance of one complete operation of the machine, whatever that may be. Each piece has a column of its own, and the points by which it is acted on are placed on its left hand, and the points by which it acts on other parts are placed on its right; and each working point also has its own column. The whole length of the column indicates the time occupied in performing one operation, and we divide that time into divisions most suited to the particular machine. During each division of time that a piece is in motion, an arrow up or down its column indicates the fact; and during the time of action of each working point, an arrow in its own column shows the duration of its action. The times thus shown are, of course, only relative, and not absolute time; but it would be easy to show both, by making the divisions of the columns correspond with the number of seconds or minutes during which the machine performs one operation. The arrows which point upwards indicate circular motion in the direction, screw in, and the arrows which point downwards, screw out; where the motion is linear, the downward arrow indicates motion from right to left.

Mr. Babbage then illustrated this system of notation by directing attention to the notation of the Difference Engine of Messrs. Scheütz. This machine contains several hundred different pieces, yet the trains showed at one view how each piece was acted on, and how it acted on other pieces; the Cycles gave with equal clearness the time of action of each piece. In fact, the two pieces of paper before the Section gave a complete description of the machine, and, with the drawings, rendered further explanation unnecessary.

On an Instrument for Sounding. By Robert Barklay.

The principle is based upon the compressibility and elasticity of vulcanized india-rubber discs subjected to the pressure of the fluid on all their sides, the reduction of their bulk laterally by the pressure being indicated upon a scale, while their temperature may be kept equable by the instrument being submerged for a time.

On Continuous Work in Dockyards. By Lady Bentham.

On the Mechanical Principles of Ancient Tracery. By Robert W. Billings.

On the Importance of Periodical Engineering Surveys of Tidal Harbours, illustrated by a comparison of the Surveys of the River Mersey, by the late Francis Giles, *C.E., and by the Marine Surveyor of the Port of Liverpool. By* Joseph Boult, *Liverpool.*

On the Machinery of the Universal Exhibition of Paris. By W. FAIRBAIRN, *F.R.S.*

On the mutual Influence of Capillary Attraction and Motion on Projectiles, and its application to the construction of a new kind of Rifle-shells, and Balls to be thrown from common guns. By* JAMES GALL, *Jun., Edinburgh.*

The author pronounced the principle of rifling the shot instead of rifling the gun, although inapplicable to small projectiles, to be absolutely necessary for large ones.

1. The great difficulty arose from the envelope of condensed air which accompanies every projectile. This is produced by three causes:—1. The sudden pressure and displacement of the air by the ball; 2. Friction; and 3. The attraction caused by motion. The *first* may be diminished by having the projectile pointed like a ship's bow. The *second* depends on the *surface* of the projectile. If it be rough and wet, the friction is great; if it be smooth and oily, the friction is small. This was illustrated by the action of wind on water—oil on the water forms a vacuum between, and prevents friction. The *third* depends on velocity. This was illustrated by inserting the end of a quill into the centre of a card. When we blow through the quill against a sheet of paper, the paper is attracted towards the card, instead of being blown away. The stronger the blast the nearer it comes.

2. He next showed how the projectile may receive a spiral motion *after* leaving the gun, first by the action of the air on projecting blades in front, or lateral fins thrown out by springs. But he gave the preference to the plan of rotating by means of a simple but peculiar sort of fire-wheel behind, producing a tangential force which increases the rotation when most needed.

By using smooth cylindrical shot pointed in front and having this fire-wheel behind, *every large gun may be used as a rifle cannon* without loss of power.

3. He next showed that the envelope of condensed air being proportioned to the extent of surface and velocity, the larger the ball, the further it may be made to go. But the difficulty is that at a very great distance one projectile is likely to miss. This is remedied by building the projectile of as many or as few pieces as may be required, and dispersing them by centrifugal force, by exploding the zinc case at a certain part of its flight.

The principle was then applied to cannons which should be large but not rifled. In that case, they may be built, the chamber cast in brass or bronze; the barrel, a tube girded by broad concentric hoops, manufactured spirally like gun-barrels.

It was also suggested that the projectiles be oiled and wrapt in calico before being fired; that moveable cylinders be used in guns, so that when one is worn out another may be put in; that touch-holes be drilled in moveable rods screwed into the gun, and that the screw be run on different diameters, so that the enemy cannot renew them if they be spiked; and that experiments by actual gunnery be preceded by experiments in water, which represent nearly the same phænomena at a small velocity that occur in air at a high velocity.

On a Momentum Engine. By WILLIAM GORMAN.

This engine consists of a wheel, having radial scoop-shaped vanes or blades, driven round by jets or streams of fluid projected tangentially against their extremities, which streams describe spiral paths by contact with the revolving blades, and are discharged near the centre of the wheel where the velocity is small, after having imparted to the wheel as much of their motive power as possible.

A steam-engine on this principle was substituted for a high-pressure cylinder steam-engine, was supplied with steam from the same boiler, and was set to drive the same machinery, which it did in a satisfactory manner, although working under great disadvantages.

The momentum steam-engine has been in regular use for nearly two years, and has

* See Architect's and Civil Engineer's Journal for October 1855.

given every satisfaction. It has not required any repairs, gives no trouble, and is in as good working condition as when it was set to work in 1853. For details see the 'Civil Engineer and Architect's Journal,' October 1855.

On a Pressure Water-Meter. By WILLIAM GORMAN.

This water-meter contains a vane-wheel, driven round by the water to be measured, which is supplied at the periphery of the wheel and withdrawn at the centre ; the principle of action being the same as in the engine above described. The openings for the supply of the water are regulated by self-acting loaded valves, which contract these orifices when the flow is small, and prevent the stream from becoming too feeble to move the vane-wheel. The revolutions of the vane-wheel are registered by a train of wheel-works*.

This meter has been in use in various works in Glasgow since 1852, and has given ample satisfaction. It is not subject to derangement ; and should it require adjustment or repair, it can be taken away without interfering with the water supply. For details see 'Civil Engineer and Architect's Journal,' October 1855.

On the Measurement of Ships. By ANDREW HENDERSON, *C.E.*

On Working a Steam-engine with Rarefied Air. By M. HOLDEN.

Mr. Holden described an experiment made under his observation in 1809, which showed the applicability of rarefied air to an engine instead of steam.

On a Compass independent of Local Attraction. By ROBERT JAMIESON, *C.E.*

On a new Air-Pump exhibited by JAMES LAING.

The principal peculiarity was dispensing with the valve, two pistons being placed in one cylinder, so as to act as valves to each other.

On the Structure of Shell Mortars without Touch-hole, to be discharged by Galvanic Circuit. By Professor MACDONALD.

On the Metra. By HERBERT MACKWORTH, *Government Inspector of Mines, M.Inst.C.E., F.G.S.*

The instrument called "Metra," from its including a variety of measures, is intended for the common use of mining and other engineers, for geologists, scientific travellers, &c. The portability of the instrument will induce the taking of more scientific observations by such persons. A brass box, $2\frac{3}{4}$ inches square and $1\frac{1}{4}$ inch thick, throws open at top and bottom, fastening out by a screw so as to form a measuring side $5\frac{1}{2}$ inches long.

By placing the clinonometer level at zero, and laying the side of the instrument on the rock, the strike or level course of a bed of rock may be at once found and read off on the compass, which is made as large as possible. The bottom of the compass being made of glass, the strike of the roof of a mine can be, in like manner, found, and then read off from the under side of the card. The amount of inclination in degrees or in inches of fall per yard, is found by the level. In the above cases the accuracy of reading is to $\frac{1}{2}°$. The level course or inclination of long lines can be found by the two sights. For taking the direction of highly inclined lines, one of these sights turns down, and the plummet is suspended to a screw at the other end of the instrument. A brass surveying leg, with adjusting joints, fits into a socket on

* This engine is still in good order, working regularly, and has not required any repairs. 12th May, 1856.—WM. GORMAN.

either side of the instrument. The leg can either go into a joint of stone or brick-work, or screw into a tree, timber, walking-stick, &c., according to the purpose for which it is to be applied. It will answer well for the detail surveying in mines, however contracted the working places may be. The surveys may be laid down on paper without the aid of anything but a pencil, by first adjusting the north and south line of the plan by the compass, and fastening the paper down by weights. The compass then serves as the protractor, and by the scales the distances are measured off. This method saves all calculation, ruling parallel lines, &c., and obviates some instrumental errors. The thermometer needs no remark, but that it is useful in examining ventilation. The *Goniometer* consists of an arm which can be raised up against the lid of the box, and enables the eye to measure angles, crystals, cleavage, &c. A magnifying glass is placed in one angle of the box, in the other is a tour-maline for examining rocks at the bottom of pools, or along coast lines, &c. In the bottom lid is a table of constants, suited for the objects of the different classes of observers named. By turning back the elastic band, and lifting out the small arm and sheet of mica, and adjusting the box by the spirit-level, a delicate anemometer without friction is obtained, particularly useful in ascertaining the velocity of the ventilation in the ends of mines. There are several other uses, too long to enumerate, which will suggest themselves in practice.

On an Application of Galvanic Power to Machinery. By ROBERT MAIR.

On a Screw-vent for turning Spiked Guns into use. By Dr. MARCH.

On Manœuvring Steamers. By GEORGE MILLS.

Description of the Launch of the Steamer 'Persia.' *By* J. R. NAPIER, *C.E.*

On a simple Boat Plug. By J. R. NAPIER, *C.E.*

On a new Method of Drying Timber. By J. R. NAPIER, *C.E.*

On Practical Tables of the Latent Heat of Vapours.
By W. J. MACQUORN RANKINE, *C.E., F.R.SS. L. & E.*

These tables give directly the latent heat of evaporation of one cubic foot of steam, and of æther-vapour respectively, at various temperatures and pressures of ebullition; such latent heat being given in foot-pounds by the formula

$$\tau \frac{dP}{d\tau},$$

where P is the pressure and τ the absolute temperature.

On the Operation of the Patent Laws.
By W. J. MACQUORN RANKINE, *C.E., F.R.SS. L. & E.*

While acknowledging the benefits derived from the amended patent law, the author pointed out the following defects in its operation as subjects for discussion in the Section:—1. The granting of patents for useless inventions. 2. The granting of more than one patent for the same invention during the currency of the provisional protection of the first. 3. The granting of patents for foreign inventions to persons other than the inventor or his assignee. How far these evils were to be removed by improvements in the administration of the law, and how far by amendments in the law itself, were subjects for further consideration.

On the Effects of Screw Propellers when moved at different Velocities and Depths. By G. RENNIE, *F.R.S.*

From experiments which had been made under his observation, it was desirable that the screws of vessels should be of small dimensions, light, and of rapid motion, and that their effect should be increased by their being as deeply immersed as possible. He also recommended the disc-engine for driving small screws *at high rates of velocity.*

On the Blasting and Quarrying of Rocks. By WILLIAM SIM, *of Furnace Granite Quarries, near Inverary.*

This paper gives the results of the author's experience in the blasting of a very hard description of granite by means of a system of mines, charged with gunpowder, confined in boxes, the charges varying from 1500 to 6720 lbs.

Mr. Sim considered the subject under the following heads:—

1. As to the best position in a quarry for a large blast.
2. The mode of placing and forming the mines.
3. The formula adopted for calculating the quantity of gunpowder required.
4. The placing of the gunpowder, electric wires, and safety fuse, and the stemming of the mines.
5. General results, with estimate of cost, and the applicability of the system to various descriptions of rocks.

The paper has been published in full in the 'Civil Engineer and Architect's Journal,' and in the Glasgow 'Practical Mechanics' Journal' for October 1855.

On the Transmission of Time Signals. By Professor C. PIAZZI SMYTH, *Astronomer Royal of Scotland.* (See Section A.)

An Account of Experiments on Combustion in Furnaces, with a view to the Prevention of Smoke. By Dr. TAYLOR.

On the Friction Break Dynamometer. By JAMES THOMSON, *A.M., C.E., Belfast.*

In this paper Mr. Thomson explained the nature and principles of the Friction Break Dynamometer, characterizing it as a highly valuable apparatus for the measurement of mechanical power. He turned special attention to matters having important bearings on its successful employment in practice, and to the consideration of which he had been led by experience in its use on the large scale.

The chief difficulties to be contended with, he stated as follows:—

1. The heat generated in the consumption of the mechanical power.
2. Vibration or even entire instability of the arm of the break due to ovalness or other imperfections of the friction drum.
3. Tremor of the driving shaft occasioned by alternate sticking and slipping of the drum in its friction blocks, instead of steady slipping.

In regard to these matters he made statements and explanations to the following effect:—Unless the drum be very large with reference to the power to be consumed by it, the heat generated by the friction usually requires to be carried off by streams of water carefully distributed over the drum. On the proper distribution of the water, and its regularity of supply, much of the success of the apparatus depends, since great irregularities in the friction are liable to result from imperfect arrangements for the water supply.

In the practical employment of the friction break dynamometer it is often necessary to form the drum in two halves, in order that it may be got into its place on the driving shaft. This arrangement, however, is often a source of great detriment to the working of the apparatus, on account of the difficulty or impossibility of bringing the two halves of the divided drum so correctly together as to form a sufficiently perfect cylindrical surface for producing a uniform friction. In cases therefore in

which the dividing of the drum cannot be avoided, the greatest possible care ought to be taken in effecting a correct and secure union of the two parts. He had on some occasions diminished very materially the inconvenience arising from vibrations of the arm, by connecting a spring balance with the scale for bearing the weights, in such a way as to make the arm tend to stable equilibrium in the position intended for it when working.

It very frequently happens that, from no clearly apparent or controllable cause, a violent torsional tremor occurs in the friction drum and driving shaft; while through some very slight change of circumstances, such as a change in the heat of the drum, or in the mode of application of the water, or in the speed of revolution of the shaft, steadiness of motion may be instantly restored, and perhaps soon again destroyed. The origin of the tremor he attributes to one of the known laws of the friction and cohesion of bodies; namely, that the force necessary to overcome the cohesion before sliding has commenced, is usually more than the force necessary to overcome the friction of the sliding motion. The evil liable to arise from the tremor he had found to be very great, the danger to life of the by-standers in such experiments being sometimes considerable. He had himself witnessed a case in which a violent tremor occurred in the testing of a powerful water-wheel; and, on the conclusion of the experiments, the working shaft of the wheel was found to be split and twisted.

Notwithstanding the difficulties occasionally arising in the use of the friction dynamometer, however, its remarkable efficiency, when not marred by such occurrences, and the certainty of its indications when working properly, render it a most valuable apparatus for practical use in many important and delicate cases often arising for decision. It is therefore a mechanism in which improvements are much to be desired; and also in which, he is of opinion, they are likely to be found.

On a Centrifugal Pump and Windmill erected for Drainage and Irrigation in Jamaica. By JAMES THOMSON, *A.M., C.E., Belfast.*

In this paper Mr. Thomson gave explanations, with the aid of large drawings, of a centrifugal pump recently constructed, embodying the improvement of an exterior whirlpool which he had first made public in the Mechanical Section at the Belfast Meeting in 1852. He also described a windmill with its framing of very simple construction, which had been specially designed for working the pump. The apparatus was prepared for purposes of drainage and irrigation in Jamaica, the costliness of fuel and the habitual use of windmills in that island having led to the selection of the windmill in this case as the source of power. The whole apparatus was constructed in Glasgow and afterwards erected and brought into action at its destination.

On an India-rubber Valve for Drainage of Low Lands into Tidal Outfalls. By JAMES THOMSON, *A.M., C.E., Belfast.*

In this paper Mr. Thomson described a valve, composed of a flap of vulcanized india-rubber closing against a perforated plate, which he had introduced on a water-course of the Belfast Water-works. This valve on trial had proved to accomplish very efficiently the purpose for which it was intended, and which required that it should open and close with the most perfect freedom, should keep water-tight when close, and should not be liable to be hindered from closing properly by the accidental interposition of a small piece of stick or other floating object.

It was with a view to the introduction of valves of similar construction or of like principle for the discharge of water into tidal outfalls in the drainage of fens, that Mr. Thomson thought the subject worthy of the attention of the Mechanical Section. Vulcanized india-rubber valves had in late years, as was well known, been used for many purposes, and in many different forms with great advantage; but he was not aware of any cases of their employment in the manner or for the purpose he now proposed.

On Practical Details of the Measurement of Running Water by Weir Boards. By JAMES THOMSON, *C.E.*

On the Navigation of the Clyde. *By* J. F. Ure.

Concluding Address. *By* W. J. Macquorn Rankine, *C.E., F.R.SS.L.& E.*, *President of the Section.*

The papers read to this Section, though numerous and interesting, have been of moderate length, as is desirable.

The discussions have been protracted, and have elicited many important facts and suggestions.

This is characteristic of discussions on questions of practical science.

With respect to a question of physical theory, a philosophic inquirer suspends his judgment until experimental data sufficient for its solution have been obtained—and then there remains little room for dispute.

On the contrary, a question of practical science usually involves the necessity for the immediate adoption of some rule of working; and if existing data are insufficient to give an exact solution, that solution must be acted upon which the best data attainable show to be the most probable. A prompt and sound judgment on this point is one of the essential characteristics of a *practical man*—using that term in its best sense.

On such questions there is ample room, even amongst the best-informed, for difference of opinion and for discussion.

Persons acquainted only with the sectional debates might, perhaps, conclude them to be deficient in useful results; but that conclusion would be most erroneous.

We have had in this Section ample illustration of the benefit of such debates, in eliciting the results of the experience of various engineers and mechanicians, and in suggesting questions for further investigation. It is the duty of the Committee of the Section to take such questions into consideration and to recommend to the General Committee such measures as may appear necessary for their solution. Thus the single week occupied by each Annual Meeting of the Association is a period of receiving reports of work done by its members, and of planning fresh work for them; while the period of working extends over the remainder of the year.

The proceedings of this Section, during the meeting which is now about to close, have involved an unparalleled amount of business, and have been fruitful in suggesting important subjects for investigation. I think we are entitled to say, that much has been done, during this meeting, to advance mechanical science, and to promote the harmony between sound theory and good practice.

The work to be done during the ensuing year, in consequence of the recommendations from the Committee of this Section, will be finally arranged to-day by the General Committee; and I trust that we shall receive a good account of the performance and effects of that work at our next meeting at Cheltenham.

Appendix.

On some Additions to the Geology of the Arctic Regions. *By* J. W. Salter, *F.G.S., A.L.S.*

[In an accompanying map were exhibited the discoveries lately made in Arctic geology, and an attempt made to show at one view all that is now known on the subject.]

In a communication to the Geological Society, in 1853, I had the honour to demonstrate the existence of a wide-spread Upper Silurian formation in the lands which border the Polar basin in North America.

The fact, mentioned both by Conybeare and Jameson, of the chain coral being found in the limestones of Barrow's Strait, would be, in the present state of our knowledge, a sufficient proof of the existence of Silurian strata there. But it required the extensive collections made by the expedition under Capt. Austen along that strait, and those made by Penny and his comrades up Wellington Channel, to enable us to decipher the meaning of the old lists of fossils, and to show that an

uniform horizon of *Upper Silurian* limestone stretched from near the entrance of Barrow's Straits to Melville Island northwards as far as those expeditions reached, and evidently very far to the south along Prince Regent's Inlet. These collections, brought home by the officers and medical gentlemen from various points, showed so many fossils referable to the same types as our own Dudley limestone, and so entire an absence of characteristic Lower Silurian ones, that there need be no hesitation in referring the whole of the limestones, in a general way, to the Wenlock group.

The common fossils are *Rhynchonella Phoca*, *Orthoceras* and *Murchisonia*; and there are several species identical with European ones; *e. g. Pentamerus conchidium*; a trilobite (*Encrinurus lævis*); the chain-coral; *Favosites, polymorpha*, &c. The type of the numerous corals is, however, rather American than European, *Favistella* and *Columnaria* being present,—the former abundant.

The limitation of these strata to the Upper Silurian period is an independent confirmation of the inference drawn by our able friend Mr. Logan as to the age of the lowest rocks he was able to find north of the great Lawrentine chain. These strata, which were certainly shore accumulations, contained in plenty the fossils of the Clinton group (*Pentamerus oblongus, Atrypa hemisphærica*, &c., with large species of *Orthoceras*, known in North America as Upper Silurian forms). Similar species of *Orthoceras* were found far to the west in lat. 62° by Sir John Richardson, and Upper Silurian fossils have been brought by Mr. Isbister from localities nearer to Hudson's Bay. So that the evidence, as far as yet collected, all points the same way, viz. that a wide extent of Polar or circumpolar land existed, during Lower Silurian times, north of this great ridge, which land, at the commencement of the Upper Silurian period, was depressed, covered by sea, and peopled by Mollusca and Radiata like those of our own latitudes, many species being identical.

That this depression continued during the Devonian æra, we have less proof, though it may be inferred from the character of some of the shells collected on the Slave Lake by Richardson, and, as will be presently mentioned, from some of those brought from the furthest point examined by Sir E. Belcher.

One of the great points, however, established for us by the researches of the last-named officer and his associates, is the existence of a considerable marine Carboniferous formation in the highest latitudes explored.

The age of the coal plants of Melville Island was not doubtful after the statements of Drs. Lindley and Buckland; but it is satisfactory that Capt. M'Clintock should have found in that island, a degree further north than the coal, shells distinctly comparable with those of our own mountain limestone. The Rev. Prof. Haughton has recognized two British species among them; they are from lat. 76°. Winter Harbour is 75°.

In skirting the newly discovered coast-line of Albert Land, in lat. 78°, Capt. Belcher found the shore, especially at a place called Depôt Point, strewn with blocks of a whitish-gray limestone, mixed with some redder fragments, all full of beautifully preserved fossils. These he has placed in the Museum of Practical Geology. They prove to be all truly carboniferous types: corals of the genera *Clisiophyllum, Zaphrentis, Lithostrotion, Stylastræa* and *Michelinia*; Brachiopod shells, *Producti* and *Spirifers*, with *Fenestella*, and a new foraminiferous shell of a peculiarly carboniferous character, viz. a large species of *Fusulina*.

This *Fusulina, F. hyperborea*, is five times as large as the common Russian species, and is constricted in the middle. It is a most interesting example of the concurrence of similar organic forms with like geological periods. The little *Fusulina* of Moscow is no bigger than a grain of wheat, but occurs in myriads. A still smaller, rounder species is characteristic of the mountain limestone in Asia Minor; and here, in the Polar circle, another species, gigantic in comparison, occupies the same place, and keeps up the facies of the carboniferous fauna.

The corals, with one or two exceptions, are not known European species,—a fact in harmony with the previous investigations of Edwards and Haime. *Stylastræa inconferta* of Lonsdale is not, however, rare, and was first described from Russia.

The Brachiopods, as usual, are the cosmopolite forms. We cannot distinguish the two species of *Producti, P. semireticulatus* and *P. Cora*, from English fossils. And when it is remembered that these are found, wherever the Carboniferous rocks have been examined, from India to the Icy Sea, in South America, and one of them

in Australia, they would appear the most likely of all to have reached these high latitudes.

With them is a fossil which as yet has only a polar or subpolar range. Von Buch described in 1846 the few relics obtained by Keilhau in exploring a small island (Bear Island, lat. 74° 30′) between Spitzbergen and the North Cape. The cliffs were limestone, capping coal shales (with ferns), and contained the above-named *Productus Cora*, with other European species. The principal fossil was a *Spirifer* of peculiar form, which he named after its discoverer, *S. Keilhavii*, and figured in the Berlin Transactions. Curiously enough, this species, which appears to range to the Icy Sea in Russia, is the most abundant of the Arctic fossils brought home by Capt. Belcher. He found it both at Depôt Point and on the island he has called Exmouth Island, between the coast and North Cornwall. The *Productus Cora* was found *in situ* on the summit of the island, which consists of a red ferruginous sand with balls of pyrites, and capped by *reddish limestone*, which is thus proved to be carboniferous.

The age of the red sandstone is equivocal. On the main land it is interstratified with a fissile greywacke grit, which forms considerable cliffs stretching away to the eastward, to North Yorkshire and Cardigan Straits, on the shores of which a blackish earthy limestone occurs, quite different to that of Albert Land, and with different fossils. There are species of *Rhynchonella, Orthis*, and *Spirifer*, which all have a Devonian aspect, and small *Producti* are associated in it with *Atrypa reticularis*, which species is never found in carboniferous rocks.

If this indication be accepted (and I think it a good one), that the Devonian system is here interposed between the Silurian plateau and the Carboniferous rocks, it would be satisfactory; and it is worth while to remember here, that in the easterly trend of these rocks Dr. Sutherland discovered a considerable formation of stratified sandstones along the north-eastern end of Baffin's Bay. I have provisionally given them the same colour. But nothing is known of the intervening ground.

The terminal member of the Palæozoic series, the Permian, is not yet traced in Polar America. But in Spitzbergen it has long been known, and we are indebted to Prof. De Koninck for a valuable list, chiefly European species, from thence. The *Productus horridus* and *P. cancrini, Spirifer alatus* and *S. cristatus*, are too well known to need any comment. They were collected at Bell Sound by M. Robert, in a latitude as high as that of Albert Land.

And now we come to the most interesting part of the Geology of the Arctic Basin, for I must be permitted, with the evidences before cited of an ascending section northwards, to call it so.

The reddish limestone forming the cap of Exmouth Island before referred to, is clearly, from its fossils, of carboniferous date. But in building the cairn on the summit, the fragments of limestone were carefully examined, and some of them at least contained bones of Vertebrata, which, under Prof. Owen's examination, have turned out to be *Ichthyosaurus*! Sir Edward Belcher assures me there was no perceptible difference between the fragments with bones and those with the Carboniferous shells above quoted. Yet this similarity of composition need not prevent our inferring that on this summit we have an outlying patch of Oolitic or Liassic rocks brought into close contact with the old limestone.

And as confirming the idea of the fossils being here *in situ*, and not drifted masses, Capt. M'Clintock had the good fortune to discover oolitic or lias fossils, *Ammonites, Spirifers, Pecten*, &c., in Prince Patrick's Land, lat. 76° 30′, long. 117°. These are quoted in the Royal Dublin Society's Journal for Nov. 1854. By referring to the map, it will be seen that the trend from this point to Exmouth Island follows nearly the direction E. by N. which the Carboniferous formation takes in its range from Melville Island to Albert Land. Science is greatly indebted to both these gallant officers for their exertions.

In the Dublin Journal above quoted are some excellent observations by Dr. Scouler on the Tertiary (miocene probably) flora of W. Greenland; but these do not come within the object of this communication. It is worth while, in conclusion, to observe, that elevation of the land has taken place since the period of the (drift?), for Arctic shells imbedded in it were found by the former expedition as far as 500 feet above the sea-level, and Capt. Belcher has found bones of large Vertebrata (whales?) at even greater elevations.

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Dashwood, Charles, Thomage, Norfolk.
Da Silva, Johnson, Percy Cross House, Fulham near London.
Davie, William, LL.D., (Town Clerk), Glasgow.
Dawson, J. W., Montreal, Canada.
Deane, Henry, Clapham, London.
Dennis, J. C., F.R.A.S., 122 Bishopsgate Street, London.
Dicker, J. R., 29 Exchange Alley North, Liverpool.
Dickson, Peter, 28 Upper Brook Street, London.
Dove, Hector, 71 Hope Street, Glasgow.

Edington, Thomas, 15 Newton Place, Glasgow.
Edmiston, Robert, Elmbank Crescent, Glasgow.
Edwards, J. B., Ph.D., Berry Street, Liverpool.
Elder, David (Engineer), 19 Paterson St., Glasgow.
Elliot, Robert, Wolflee, Hawick.
Evans, G. F. D., M.D., St. Mary's, Bedford.

Everest, Lt.-Colonel George, Bengal Artillery, F.R.S., 10 Westbourne Street, Hyde Park, London.

Fawcett, John, 4 Eaton Place, Brighton.
Ferguson, James, Gas Coal Works, Lesmahagow, Glasgow.
Ferguson, Peter, Apsley Place, Glasgow.
Fielding, James, Sowerby Bridge near Halifax.
Fischel, Rev. Arnold, D.D., 4 Great George Square, Liverpool.
Fleming, John, 31 Whitevale, Glasgow.
Forbes, Rev. John, D.D., 100 West Regent Street, Glasgow.
Forbes, Rev. John, Symington Manse, Biggar, Scotland.
Fowler, Richard, M.D., F.R.S., Salisbury.
Fraser, James P., 58 Buccleuch Street, Glasgow.
Frazer, Daniel, 9 Mansfield Place, Glasgow.
Frere, Capt., R.A., Gourock Castle near Glasgow.

Gale, Peter, 69 Marlborough Street, Dublin.
Gassiot, John P., F.R.S., Clapham Common, London.
Gemmell, Andrew, 38 Queen Street, Glasgow.
Gemmell, Thomas, 19 Elmbank Crescent, Glasgow.
Gerard, Henry, 110 Canning Street, Liverpool.
Gibson, Thomas F., 124 Westbourne Terrace, Hyde Park, London.
Gillis, F. L., Basnett Street, Liverpool.
Gourley, Daniel De la C., M.D., Regent's Park, London.
Grant, Robert, Somerset House, Strand, London.
Grantham, John, C.E., Liverpool.
Greenhalgh, Thomas, Bolton-le-Moors.
Greenwood, William, Stones, Todmorden, Lancashire.
Griffin, Charles, Glasgow.

Hall, Hugh F., 16 Everton Terrace, Liverpool.
Hancock, John, Lurgan, Co. Armagh.
Harcourt, Rev. L. Vernon, West Dean House, Chichester.
Harkness, Robert, F.R.S., F.G.S., Professor of Geology in Queen's College, Cork.
Hartnup, John, F.R.A.S., Observatory, Liverpool.
Hassall, Arthur Hill, 8 Bennett Street, St. James's Street, London.
Hawkes, William, Eagle Foundry, Birmingham.
Hector, James, 57 Inverleith Row, Edinburgh.
Hepburn, Robert, 8 Davis Street, Berkeley Square, London.
Hervey, The Rev. Lord Arthur, Ickworth, Suffolk.
Higgins, Rev. Henry H., M.A., Rainhill, Liverpool.
Highley, Samuel, F.G.S., London.
Hill, Laurence, Port Glasgow.
Hill, William, F.R.A.S., Worcester.
Hodgkinson, Rev. G. C., M.A., The Lodge, Louth, Yorkshire.
Hudson, Robert, F.R.S., Clapham Common, London.
Hunt, Robert, F.R.S., Keeper of Mining Records, Museum of Practical Geology, Jermyn Street, London.
Huntington, Frederick, F.R.C.S. Engl., 19 George Street, Hull.

Jackson, Rev. William, M.A., St. John's Wokington.
Jacob, W. S., F.R.A.S., Madras.
Johnston, A. Keith, 4 St. Andrew Square, Edinburgh.
Jones, Rev. Henry Halford, Cemetery, Manchester.
Jones, John, 34 Chapel Street, Liverpool.

Kay, Alexander, Atherton Grange, Wimbledon Park, Surrey.
Kaye, Robert, Mill Brae, Moodresburn, Glasgow.
Keddie, William, 15 North Street, Mungo Street, Glasgow.
King, Alfred, 1 Netherfield Road South, Liverpool.
King, Alfred, Jun., Everton, Liverpool.
King, James, Levernholme, Hurlet, Glasgow.
Kirkwood, Anderson, 246 Sauchiehall Street, Glasgow.

Lankester, Edwin, M.D., F.R.S., 8 Savile Row, London.
Latham, R. G., M.D., F.R.S., Greenford, Middlesex.
Lawson, John, Mount Blue, Camlachie.
Lees, Samuel, Park Bridge, Ashton-under-Lyne.
Liddell, John, 8 Clelland St., Glasgow.
Lister, Dr. John, F.G.S., Shibden Hall near Halifax.
Lister, Rev. William, Bushbury, Staffordshire.
Liveing, G. D., St. John's College, Cambridge.

Lorimer, Rev. J. G., D.D., 6 Woodside Place, Glasgow.
Low, David, Mayfield, Edinburgh.

MacArthur, Richard J. W., 129 St. Vincent Street, Glasgow.
McCallum, Archibald K., M.A., House of Refuge, Duke Street, Glasgow.
McCann, James, F.G.S., Liverpool.
McClelland, James, jun., 10 Claremont Terrace, Glasgow.
McFarlane, Very Rev. Principal, University, Glasgow.
McFarlane, Walter, Saracen Foundry, Glasgow.
MacGeorge, Andrew, jun., 21 St. Vincent Place, Glasgow.
MacGregor, James Watt, Wallace Grove, Glasgow.
McGregor, A. Bennett, 19 Woodside Terrace, Glasgow.
McIlwraith, H., Greenock.
McKenzie, Alexander, 89 Buchanan St., Glasgow.
Mackinlay, David, Pollockshields, Glasgow.
MacLaren, Charles, Moreland Cottage, Grange Lone, Edinburgh.
McLaren, John, Seabank, Gourock.
McLintock, William, Lochinch, Pollokshaws, Glasgow.
McNab, John, Edinburgh.
McTyre, William, M.D., Maybole, Ayrshire.
Macvicar, Rev. J. Gibson, D.D., Moffat near Glasgow.
Malahide, Talbot de, Lord, Malahide Castle, Malahide, Ireland.
Malcolm, Andrew G., M.D., 49 York Street, Belfast.
Martindale, Nicholas, 15 Hanover Street, Liverpool.
Maule, Rev. Thomas, M.A., Partick, Glasgow.
May, Charles, F.R.S., 3 Great George Street, Westminster.
Melly, Charles Pierce, Liverpool.
Miles, Rev. C. P., M.D., 14 Buckingham Terrace, Glasgow.
Mirlees, James B., 94 West Street, Tradeston, Glasgow.
Mitchell, George, Glasgow.
Moffatt, T., M.D., F.R.A.S., Hawarden.
Moir, James (City Councillor), 174 Gallowgate, Glasgow.
Muir, William, Britannia Works, Manchester.
Murdoch, J. B., 195 Bath Street, Glasgow.
Murray, William, F.G.S., 160 West George Street, Glasgow.

Napier, James R., 26 Newton Place, Glasgow.
Napier, Robert, West Chandon, Gareloch, Glasgow.
Neale, Edward V., West Wickham, Kent.
Neild, William, Mayfield, Manchester.
Neilson, Walter, 28 Woodside Place, Glasgow.
Newmarch, William, Secretary to the Globe Insurance, Cornhill, London.
Nicolay, Rev. C. G., King's College, Strand, London.

Oldham, James, C.E., Austrian Chambers, Hull.
Outram, Thomas, Greetland near Halifax.

Pare, William, Seville Iron Works, Dublin.
Paterson, William, 100 Brunswick St., Glasgow.
Peach, Charles W., Custom House, Wick.
Penny, Frederick, Professor of Chemistry in the Andersonian University, Glasgow.
Percy, John, M.D., F.R.S., Museum of Practical Geology, Jermyn Street, London.
Petrie, William, Ecclesbourne Cottage, Woolwich.
Pochin, Henry Davis, Manchester.
Potchett, Rev. William, M.A., The Vicarage, Grantham.

Rainey, Harry, M.D., 10 Moore Place, Glasgow.
Ramsay, Andrew C., F.R.S., Director of the Geological Survey of Great Britain, Museum of Practical Geology, Jermyn Street, London.
Randolph, Chas., Pollockshields, Glasgow.
Rankin, Rev. Thomas, Huggate, Yorkshire.
Rankine, W. J. Macquorn, C.E., F.R.S. L.&E., 59 St. Vincent Street, Glasgow.
Reid, James, Glasgow Academy, Glasgow.
Ritchie, Robert, C.E., 16 Hill Street, Edinburgh.
Roberton, James, Gorbals Foundry, Glasgow.
Roberts, John, 13 Parliament Terrace, Liverpool.
Robinson, C. B., The Shrubbery, Leicester.
Robinson, M. E., 116 St. Vincent Street, Glasgow.
Robson, Neil, C.E., 95 Wellington St., Glasgow.
Ronalds, Francis, F.R.S.
Roscoe, Henry E., University College, London.
Roth, Dr. Mathias, 16 *a* Old Cavendish Street, London.

Round, Daniel George, The Hange, Tividale, Staffordshire.
Rowand, Alex., Linthouse near Glasgow.
Russell, James, jun., Falkirk.

Seligman, H. L., 135 Buchanan Street, Glasgow.
Scott, Montague D., B.A., Hove, Sussex.
Sim, William, Furnace near Inverary.
Shaw, Norton, M.D., Secretary to the Royal Geographical Society, 3 Waterloo Place, London.
Shewell, John T., Rushmere, Ipswich.
Sleddon, Francis, 2 Kingston Terrace, Hull.
Sloper, George Elgar, jun., Devizes.
Smith, Jas., St. Vincent Street, Glasgow.
Smith, George, Port Dundas, Glasgow.
Smith, G. Cruickshank, 19 St. Vincent Street, Glasgow.
Smith, Robert Angus, Ph.D., 20 Grosvenor Square, Manchester.
Smith, William, Eglinton Engine Works, Glasgow.
Smyth, John, jun., M.A., C.E., Milltown, Banbridge, Ireland.
Sorby, Henry Clifton, F.G.S., Broomfield, Sheffield.
Sorby, John Clifton, Park, Birkenhead.
Spence, Peter, Pendleton, Manchester.
Spence, William, F.R.S., V.P.L.S., 18 Lower Seymour Street, Portman Sq., London.
Spence, W. B., 18 Lower Seymour Street, Portman Square, London.
Spens, William, 78 St. Vincent Street, Glasgow.
Steele, William, 25 Blythswood Square, Glasgow.
Stevelly, John, LL.D., Professor of Natural Philosophy in Queen's College, Belfast.
Stewart, Balfour, 13 Rutland Street, Edinburgh.
Stuart, Wm., Rumford Place, Liverpool.
Sutton, Edwin, 44 Winchester Street, Pimlico, London.

Talbot, William Hawkshead, Wrightington near Wigan.
Taylor, William Edward, Blackburn.
Terry, John, 15 Albion Street, Hull.
Teschemacher, E. F., 1 College Road, Highbury Park, London.
Thomson, Allen, M.D., Professor of Anatomy in the University of Glasgow; The College, Glasgow.
Thomson, James, 82 West Nile Street, Glasgow.
Thorburn, Rev. William Reid, M.A., Starkies, Bury, Lancashire.
Tooke, Thomas, F.R.S., 31 Spring Gardens, London.
Towson, John Thomas, 23 Great George Square, Liverpool.
Turnbull, John, Bonhill House, Dumbartonshire.
Tuton, Edward S., Lime Street, Liverpool.
Twining, Richard, F.R.S., 13 Bedford Place, Russell Square, London.
Tyndall, John, Ph.D., F.R.S., Professor of Natural Philosophy in the Royal Institution of Great Britain, London.

Ure, John, 114 Montrose St., Glasgow.

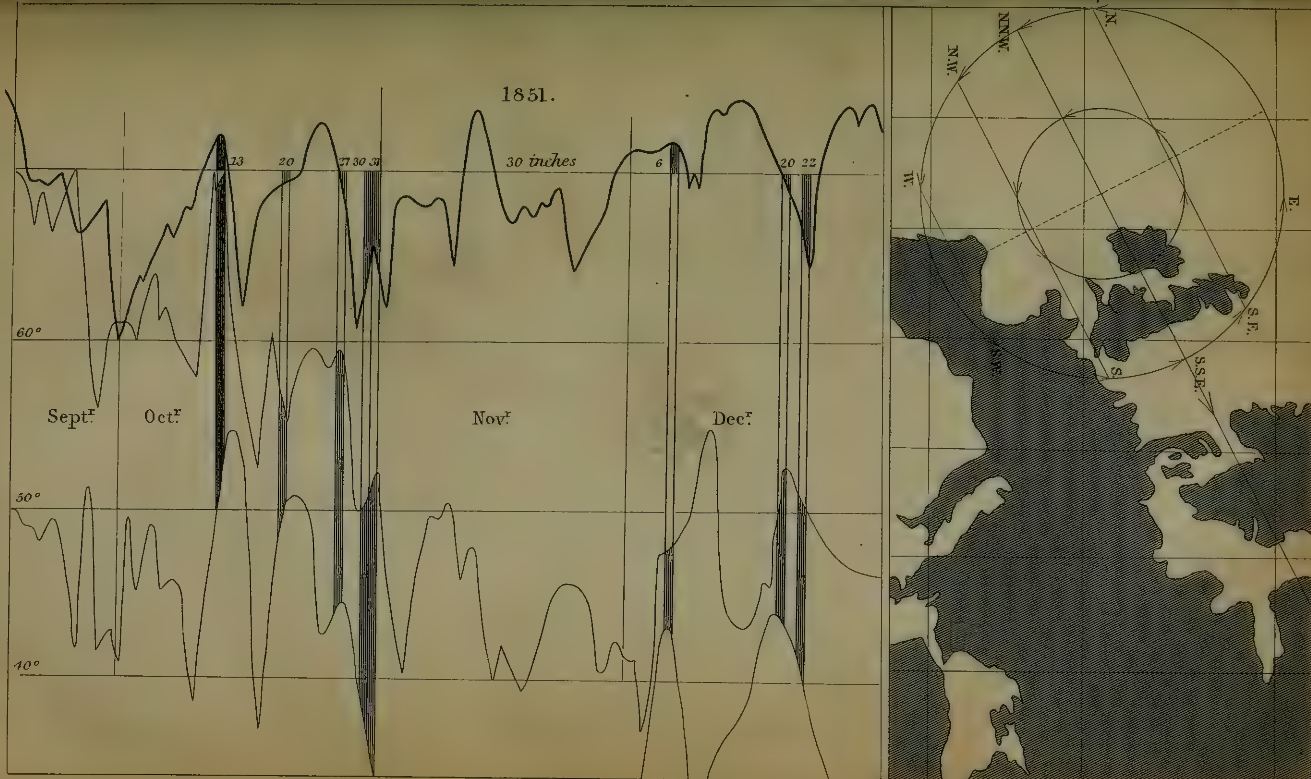
Varley, Cornelius, 1 Charles Street, Clarendon Square, London.

Walker, Charles V., Electric Telegraph, South Eastern Railway, Tunbridge.
Walker, John, 1 Exchange Court, Glasgow.
Walker, John Jas., Dollymount, Dublin.
Walsh, Richard Hussey, Professor of Political Economy in the University of Dublin; Dublin.
Warington, Robert, F.C.S., Apothecaries' Hall, London.
Watson, Ebenezer, 16 Abercromby Place, Glasgow.
Watson, James, M.D., 152 St. Vincent Street, Glasgow.
Watt, George, West Regent Street, Glasgow.
Watt, William, Flax Works, Bedford Street, Belfast.
Watts, John King, F.R.G.S., St. Ives, Huntingdonshire.
Wight, Robert, M.D., F.L.S., Grazeley Lodge, Reading.
Wilkie, John, 46 George Square, Glasgow.
Willis, William, Virginia Buildings, Glasgow.
Wilson, Hugh, 75 Glassford Street, Glasgow.
Wingate, Major, H.E.I.C.S., Bendarroch, Gareloch, Glasgow.
Woodall, John Woodall, St. Nicholas House, Scarborough.
Wornell, George, 2 Crescent, Park Town, Oxford.
Wright, Thomas, F.S.A., 14 Sydney St., Brompton, London.

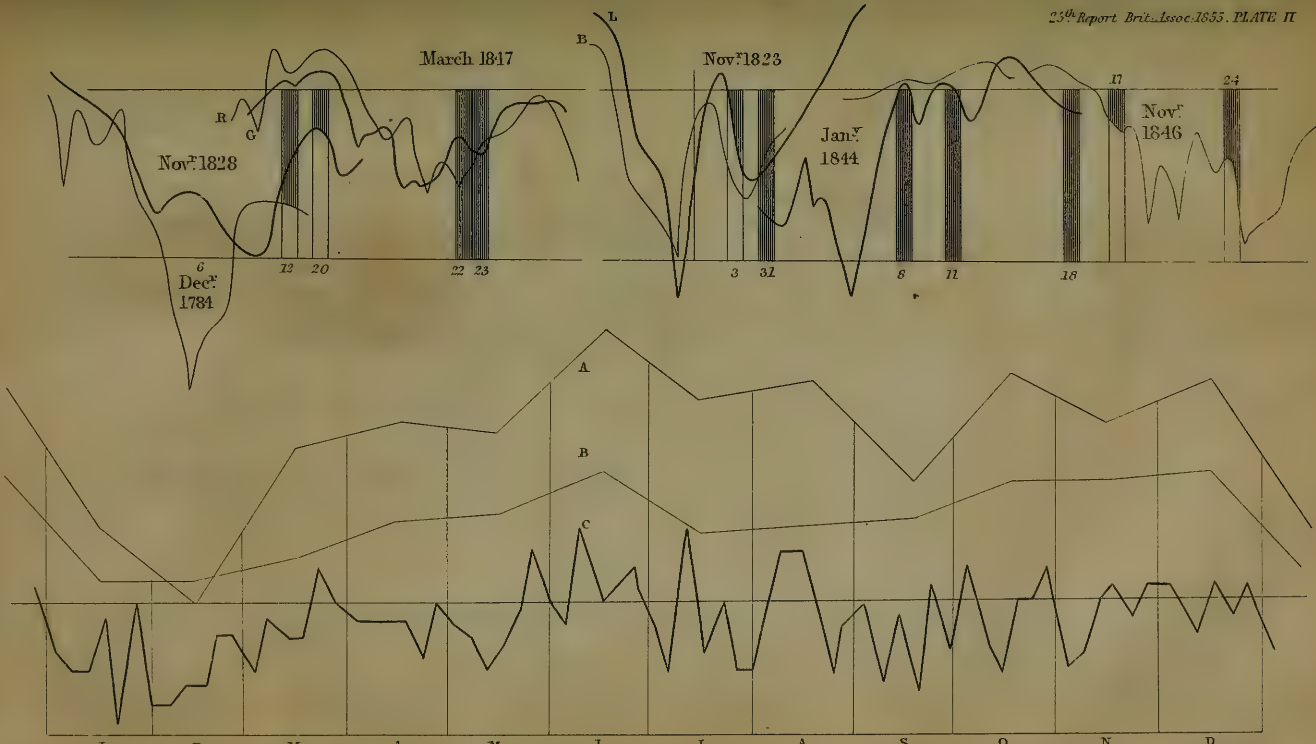
Yeats, John, F.R.G.S., Leicester House, Peckham, London.
Young, Dr. A. K., Thistle Street, Garnet Hill, Glasgow.

Zwilchenbart, Emanuel, 3 Rumford St., Liverpool.

LIST OF PLATES.


1851.
30 inches
13
20
27 30 31
6
20 22
60°
50°
40°
Septr.
Octr.
Novr.
Decr.
N.
NNW.
N.W.
W.
S.W.
S.
S.S.E.
S.E.
E.

J. W. Lowry fc.



March 1847
Nov.r 1828
6 Dec.r 1784
R
G
12
20
22
23
L
B
Nov.r 1823
Jan.y 1844
3
31
8
11
18
17
24
Nov.r 1846
A
B
C
J
F
M
A
M
J
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A
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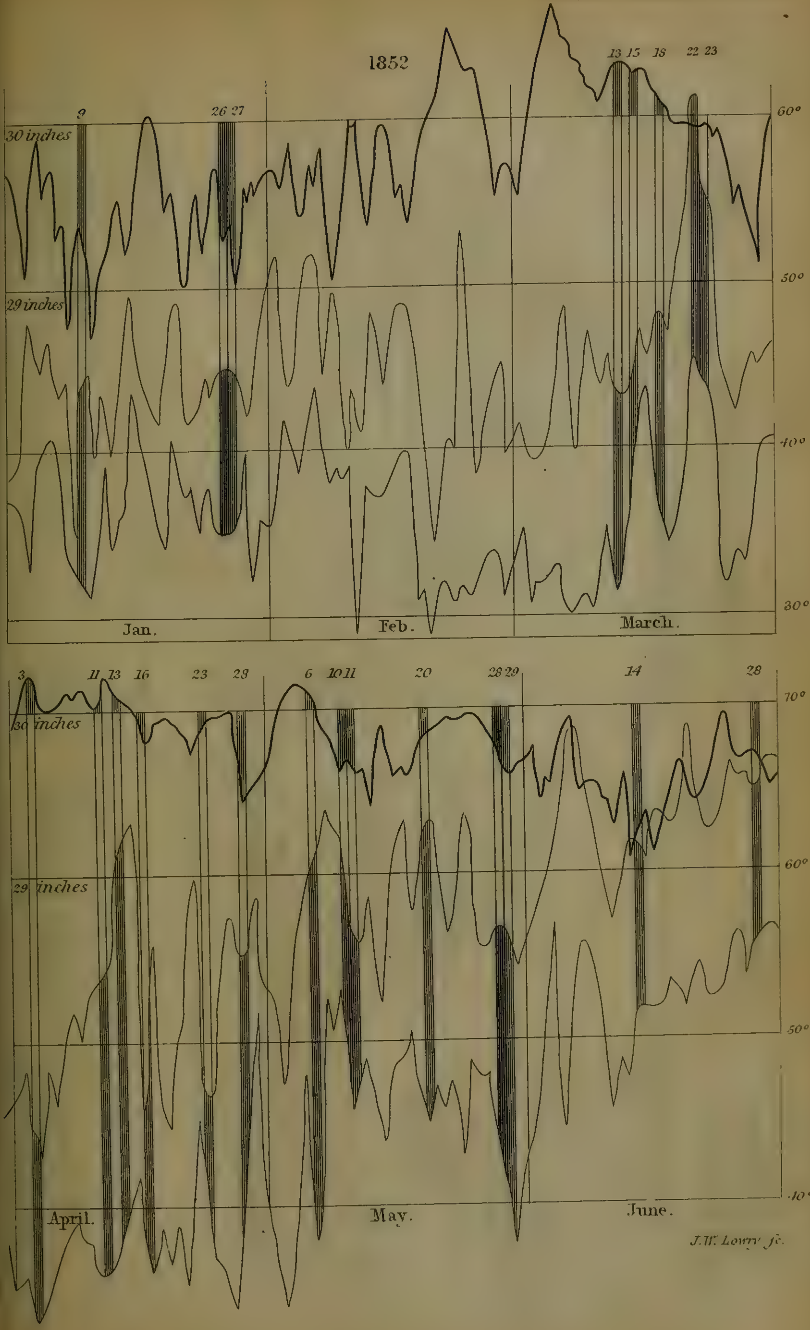
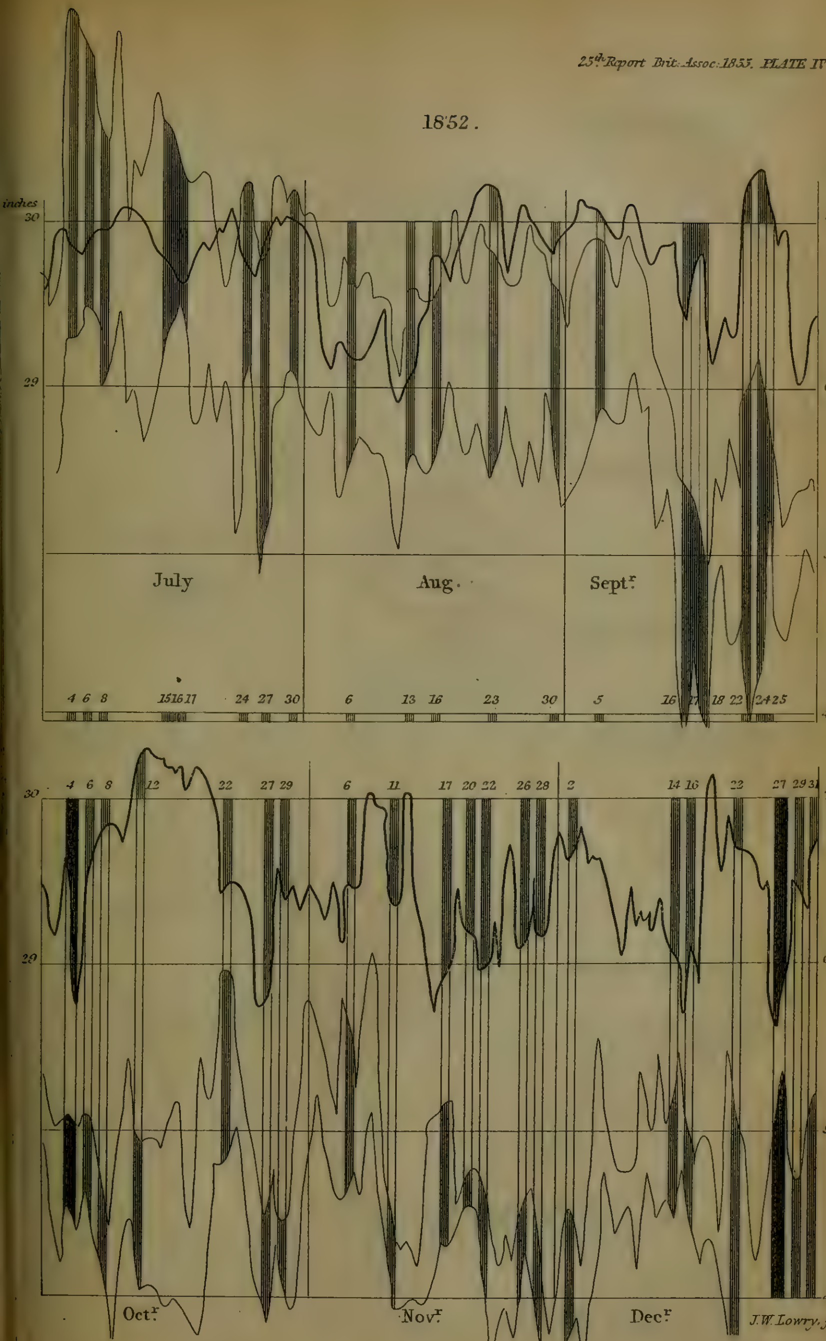
D

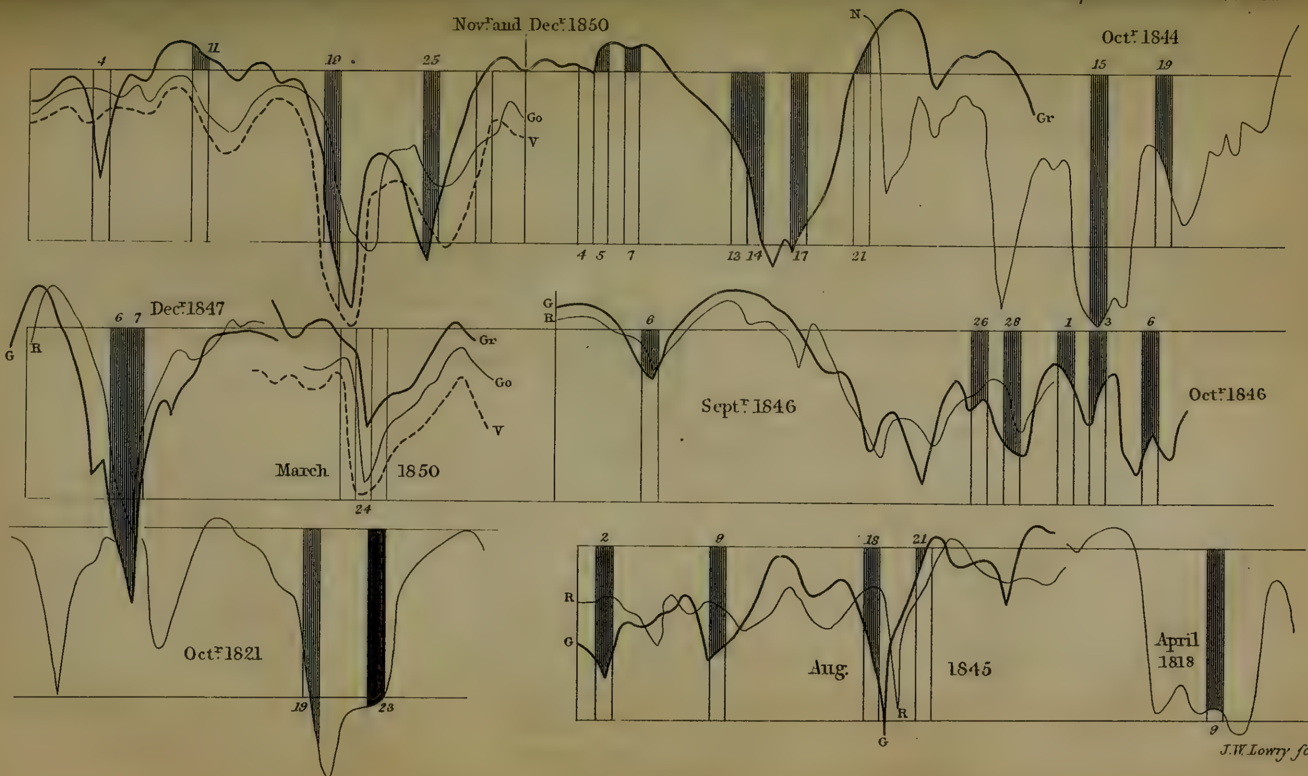
J. W. Lowry sc


1852
9
26 27
13 15 18 22 23
30 inches
29 inches
60°
50°
40°
30°
Jan.
Feb.
March.
3
11 13 16 23 28
6 10 11 20 28 29
14
28
30 inches
29 inches
70°
60°
50°
40°
April.
May.
June.
J. W. Lowry fc.

1852.



J. W. Lowry, fc.


Novr. and Decr. 1850
4
11
19
25
Go
V
4 5 7
13 14
17
21
N
Gr
Octr. 1844
15
19
Decr. 1847
6 7
G
R
March
1850
24
Gr
Go
V
G
R
6
Septr. 1846
26
28
1
3
6
Octr. 1846
Octr. 1821
19
23
2
9
R
G
Aug.
18
21
R
G
1845
April
1818
9

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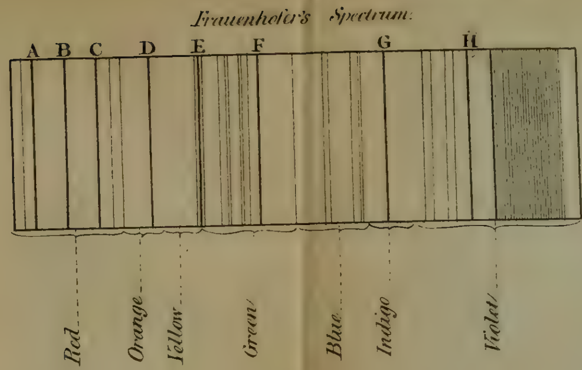
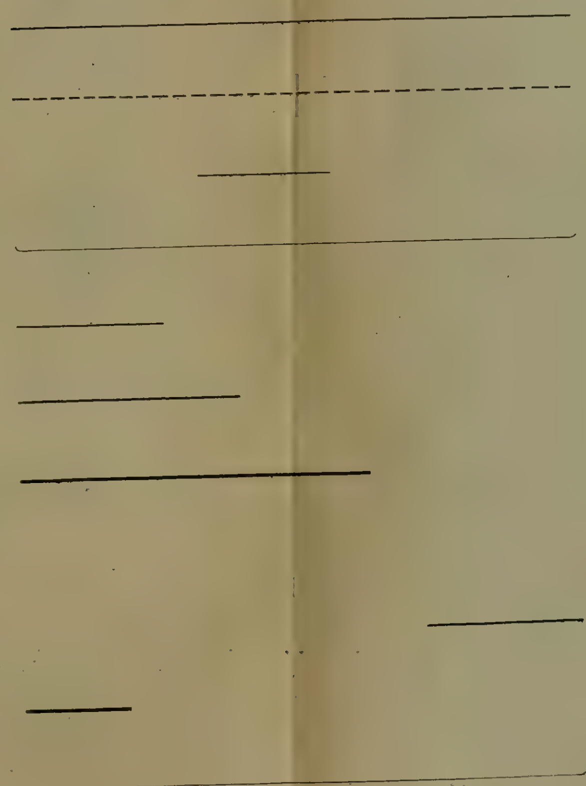
Rays admitted by the Media.





No. 1 *Transparent Glass,*
all the rays fully admitted.

No. 2 *Blue Glass,*
all partially admitted.

No. 3 *Dark Green Glass,*
green and a little blue admitted.

No. 4 *Light Green Glass,*
all deadened.

No. 5 *Ruby Glass,*
red and orange admitted.

No. 6 *Amber Glass,*
all up to green admitted.

No. 7 *Orange Glass,*
all up to indigo admitted.

Vessels containing

No. 8 *Ammonio-sulphate of Copper,*
only the violet admitted.

No. 9 *Port Wine,*
only the red admitted.

No. 10 *Ink and Water,*
all the rays deadened.

No. 11 *Black Board,*
all the rays excluded.

N.B. The Black lines indicate the rays admitted.

J. Basire, litho.

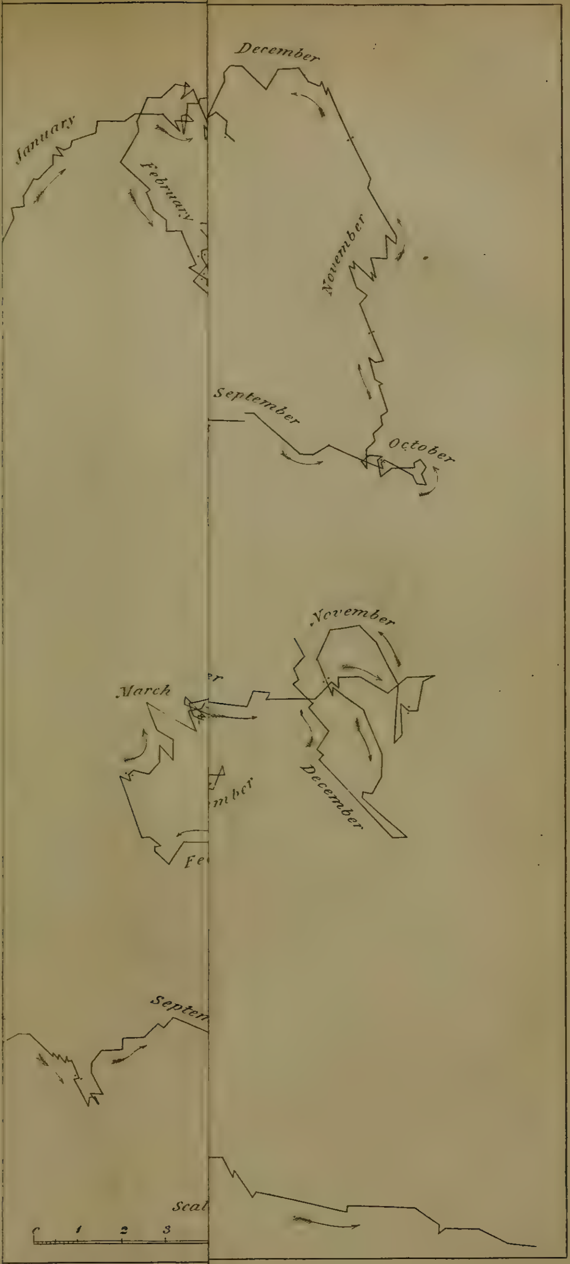
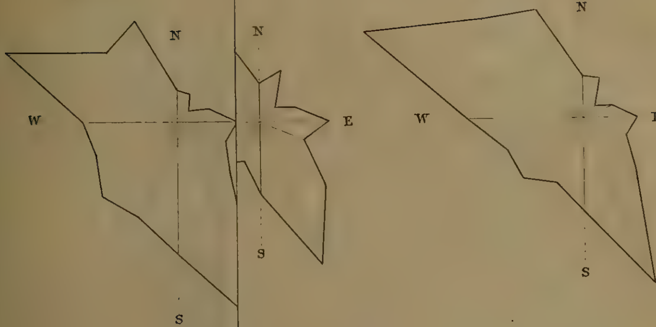

December
January
February
November
September
October
November
March
December
Septem
Scal


CHART OF THE WIND.
LIVERPOOL OBSERVATORY.
1852. 1853. 1854. 1855.
1852.
1853
1854.
1855
N
NW
NE
W
E
SW
SE
S
January

2.

1852

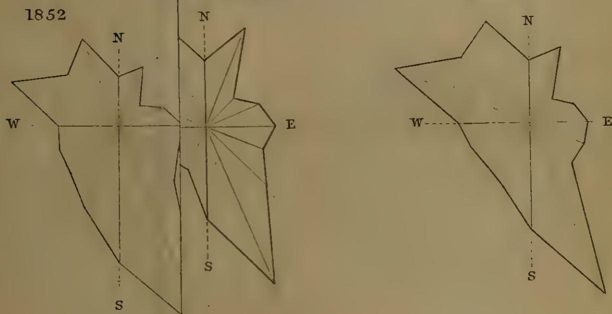
Mean



e III. Column 4.

1852

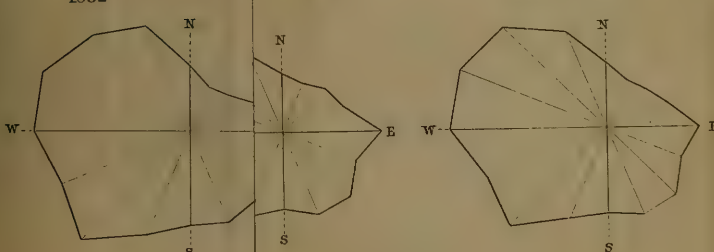
Mean



Column 6.

1852

Mean



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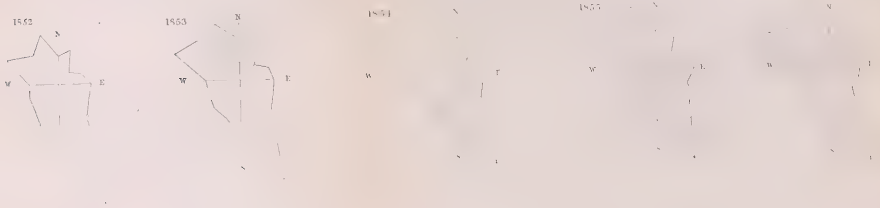
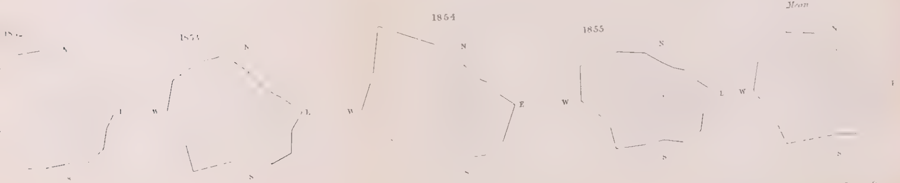
Comparative amount of horizontal motion of the AIR — See Table III. Column 2

Number of hours in which the motion of the AIR was referred to each point — See Table III. Column 4

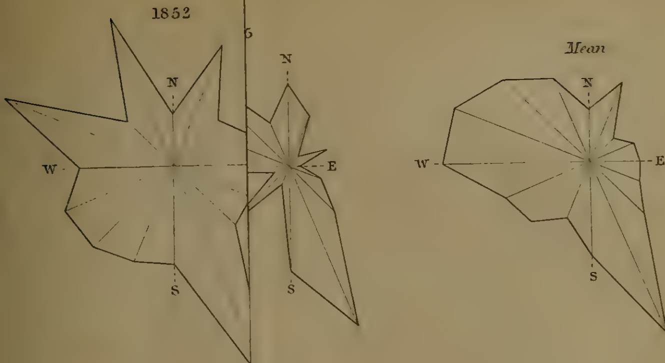


Average hourly horizontal motion of the AIR from each point — See Table III. Column 6.

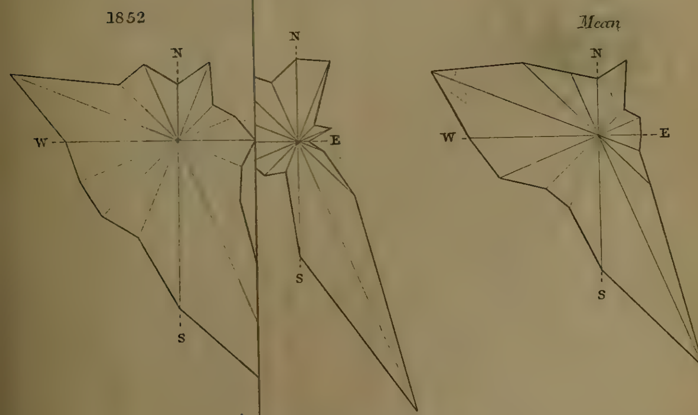


J W Lowry fc

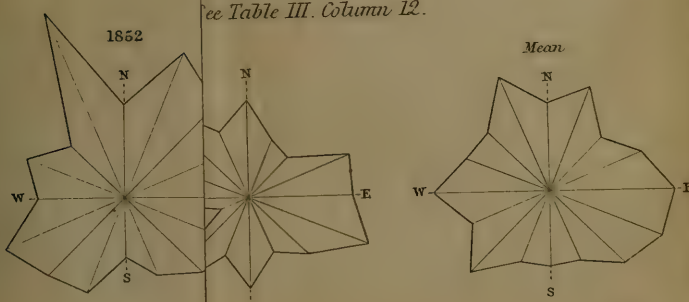
See Table III. Column 8.



III. Column 10.



ee Table III. Column 12.



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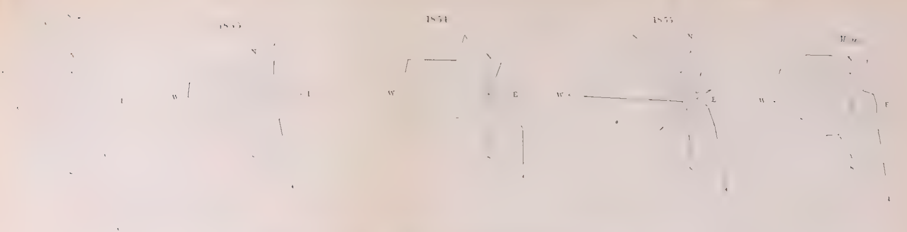
[illegible] RAIN arranged according to the direction of the Wind at the time of its falling [illegible] Table III. Column [illegible]



[illegible] RAIN [illegible] referred to the points of the compass [illegible] Table III. Column [illegible]

Average hourly quantity of RAIN that fell arranged according to the direction of the Wind. — See Table III. Column 12.

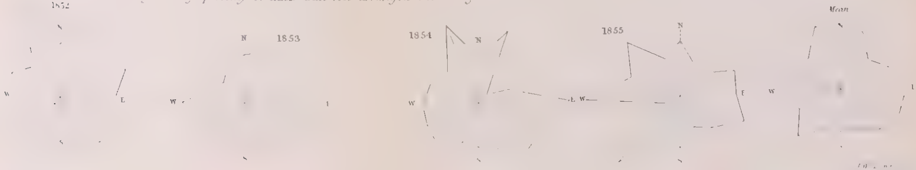


Fig. 1.

Whole Amount of Rain that fell between each hour of the day in 1852_3_4_5 See table V.

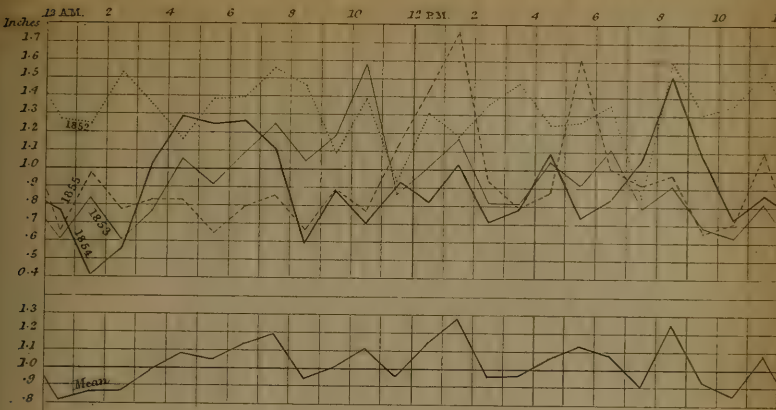
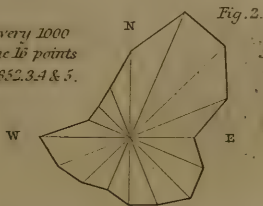


Fig. 2.

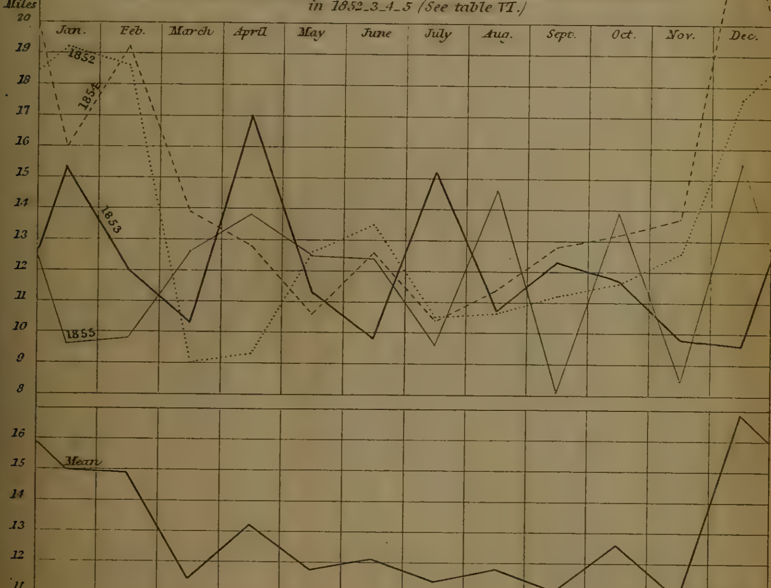
Mean quantity of RAIN to every 1000 miles of Air from each of the 16 points of the compass for the years 1852.3.4 & 5.



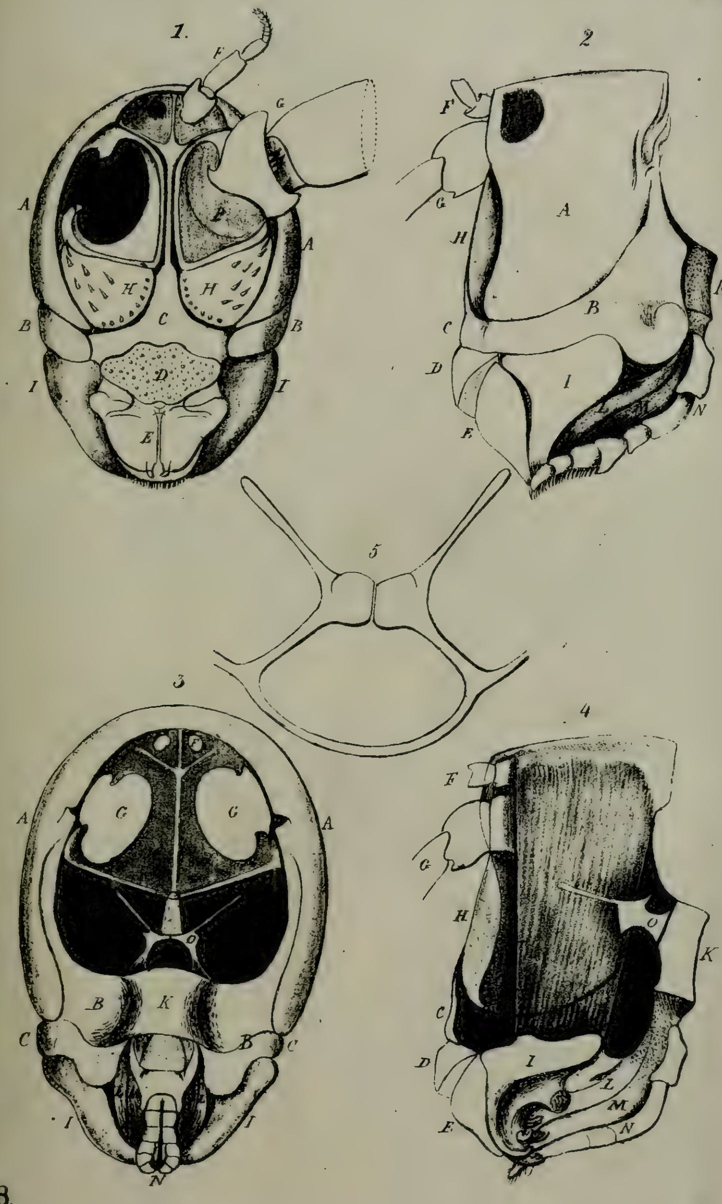
See table III Column 13

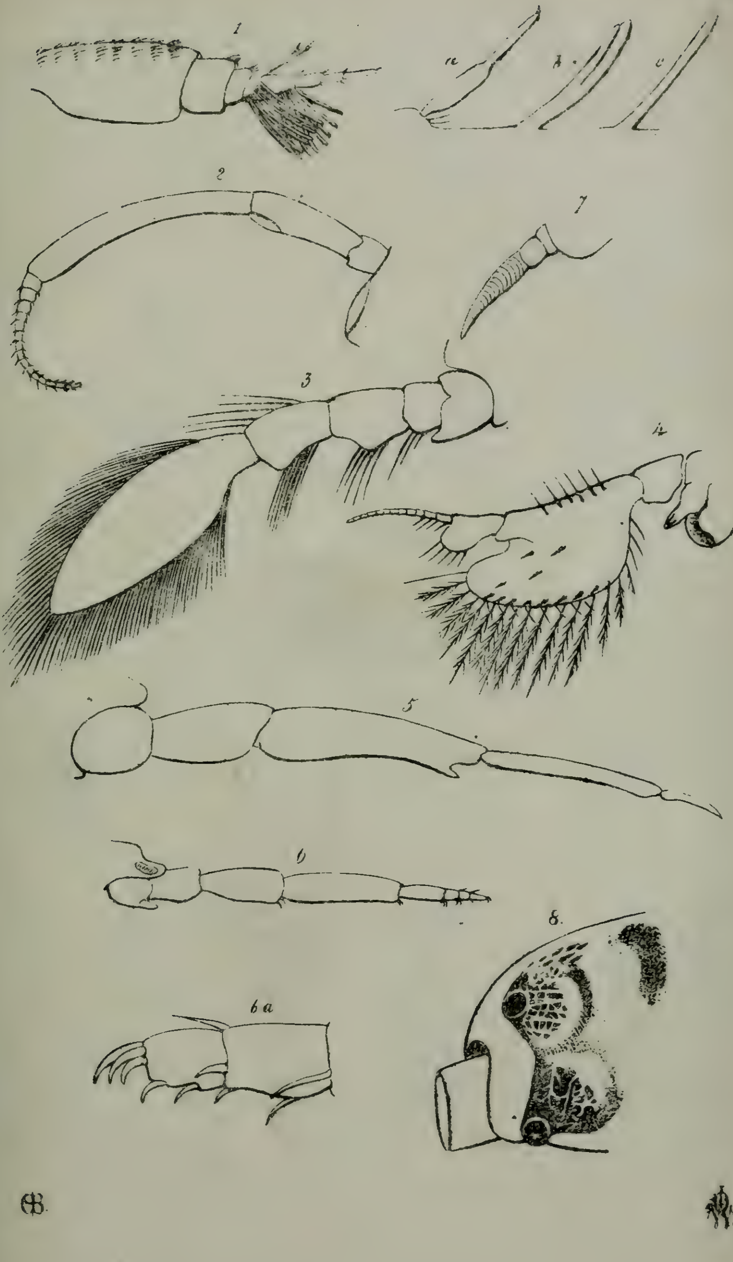
Fig. 3.

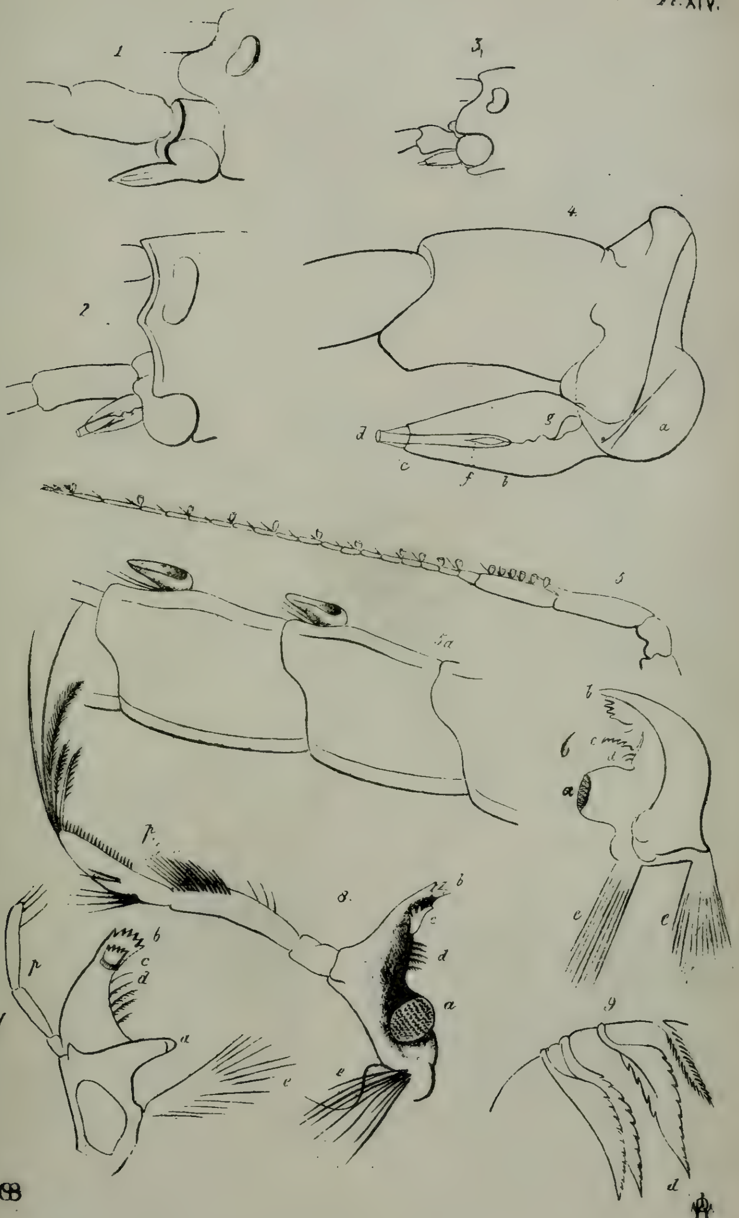
Mean hourly horizontal motion of the AIR in miles for each month in 1852_3_4_5 (See table VI.)



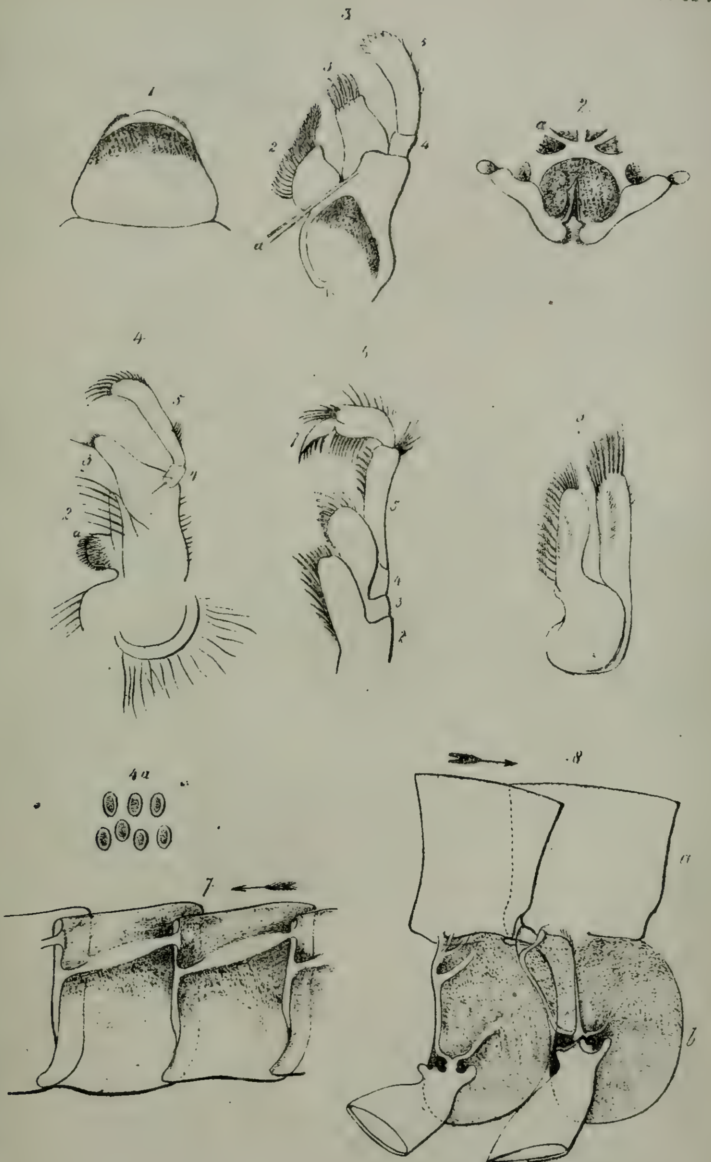
J. W. Lowry fc.


1.
2
3
4
5
A
B
C
D
E
F
G
H
I
K
L
M
N
O

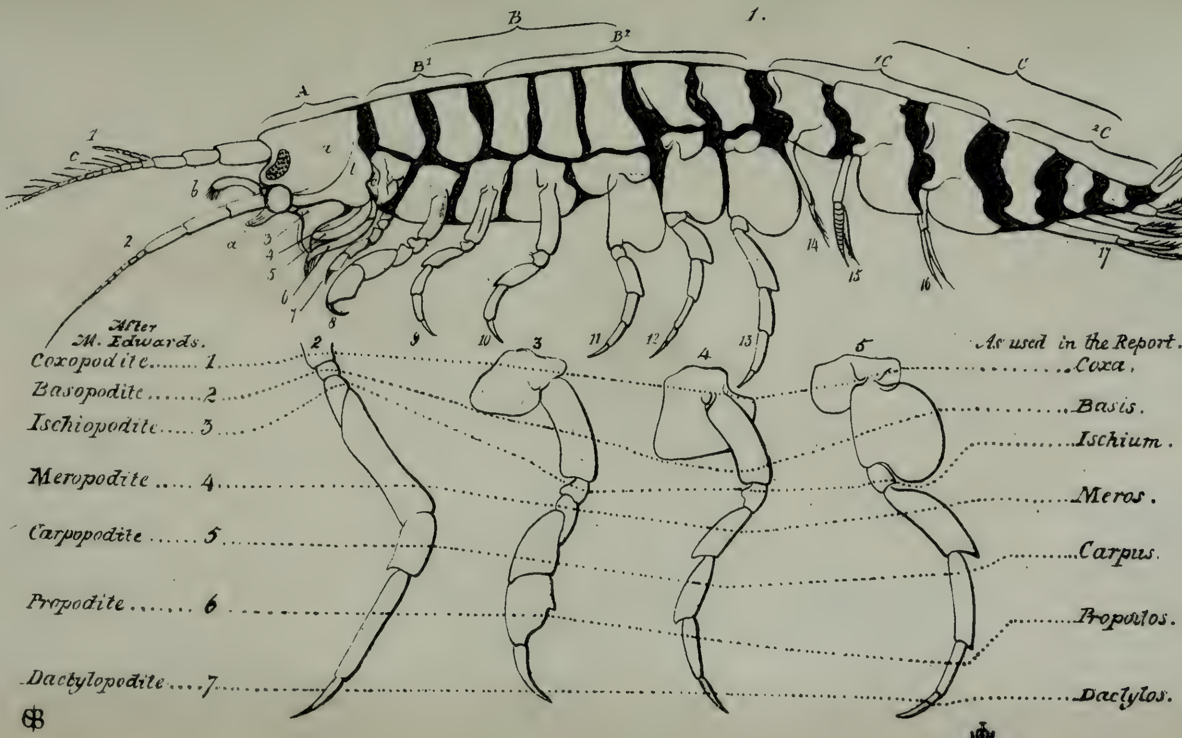

1
a
b
c
2
7
3
4
5
6
8.
6 a

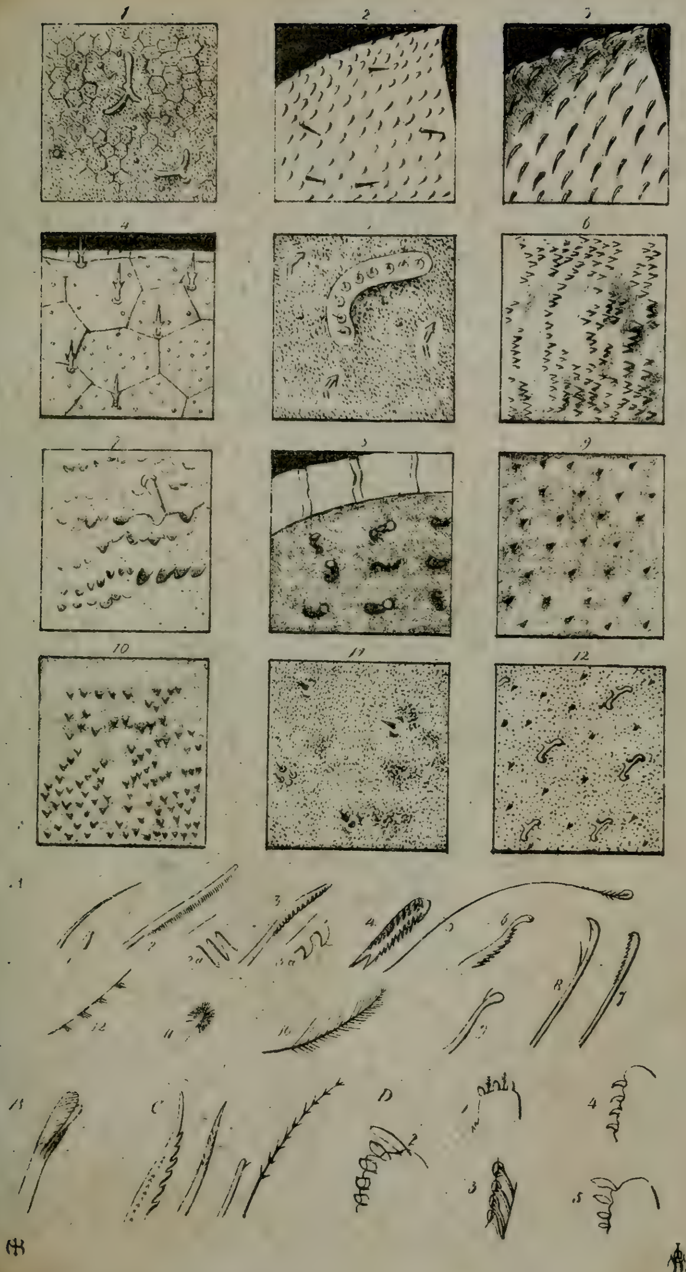

1
2
3
4
a
b
c
d
f
g
5
5a
6
a
b
c
d
e
e
7
p
a
b
c
d
e
8
p
a
b
c
d
e
9
d

Pl. XV.

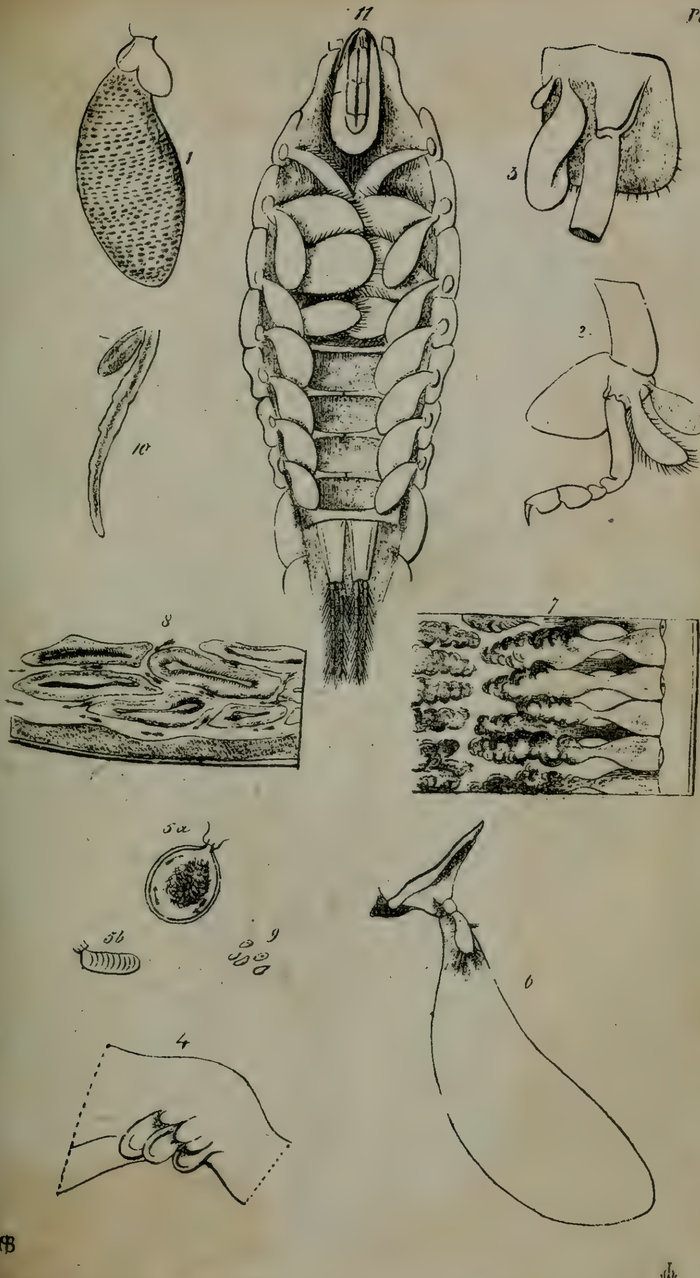


B.

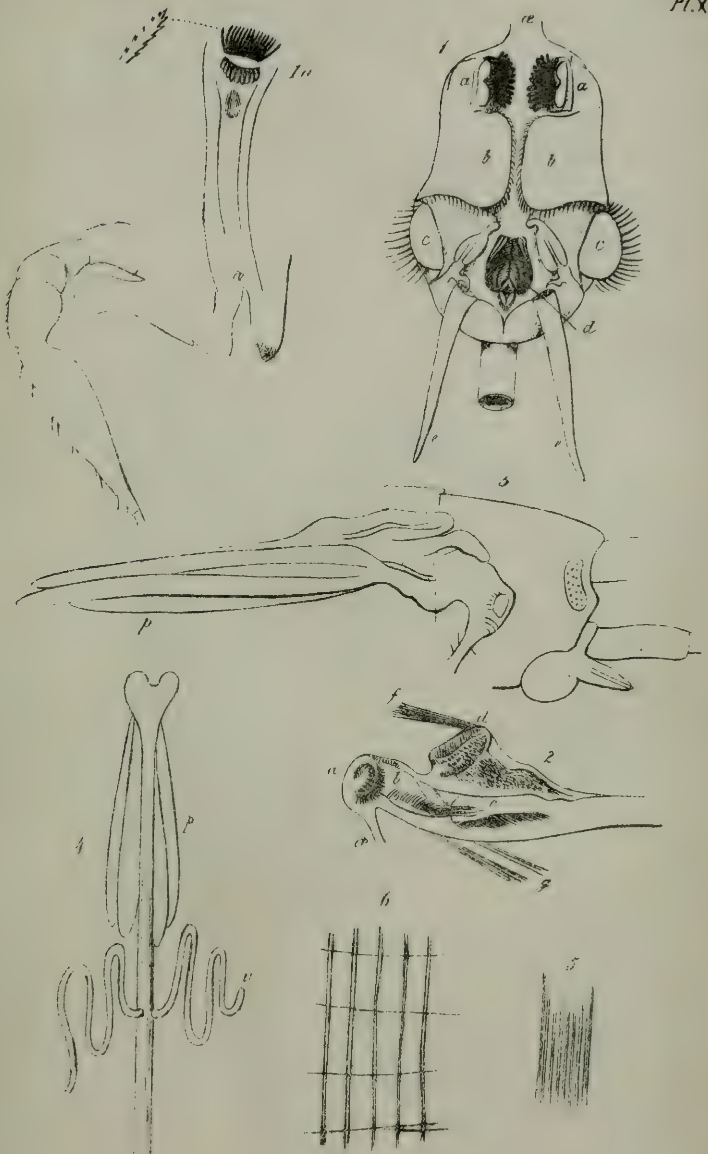

1.
A
B
B1
B2
1C
C
2C
After M. Edwards.
Coxopodite....... 1
Basopodite 2
Ischiopodite..... 3
Meropodite 4
Carpopodite 5
Propodite 6
Dactylopodite 7
As used in the Report.
Coxa.
Basis.
Ischium.
Meros.
Carpus.
Propodos.
Dactylos.



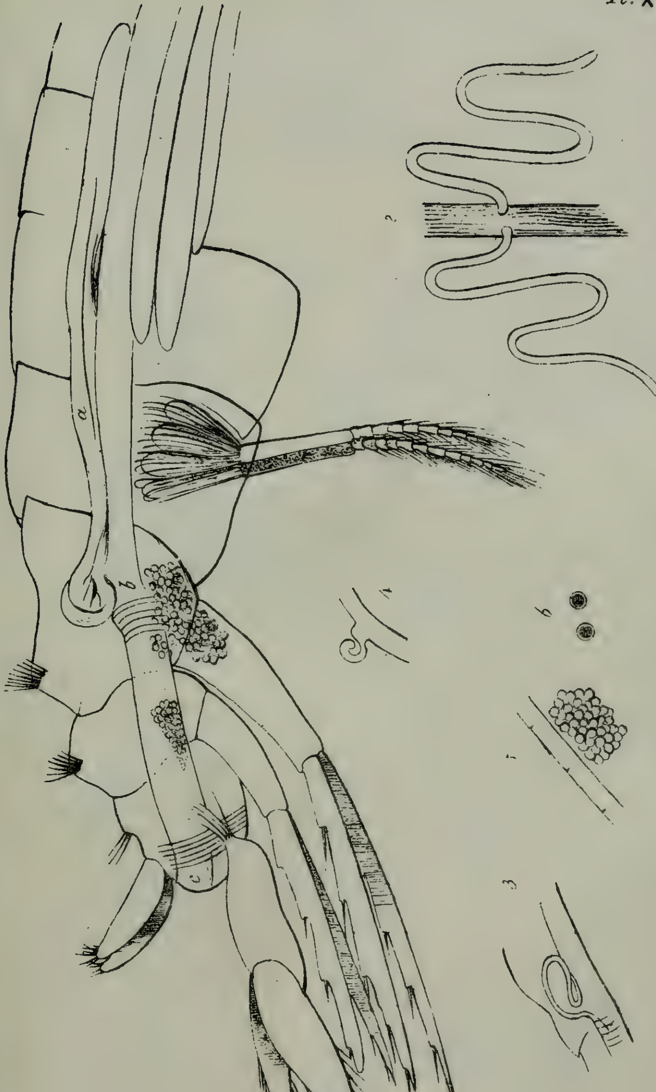
Pl XVIII.



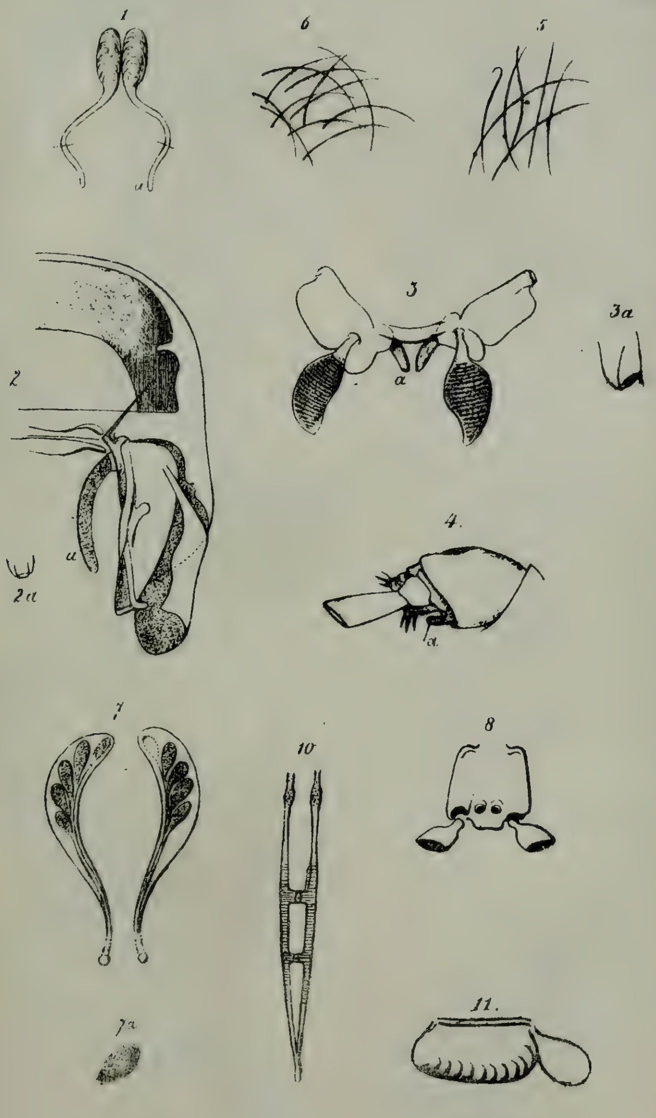
Pl. XIX



Pl. XX.



Pl. XXI.



Pl. XXII.